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THE WHITE HOUSE

October 7, 1936.

My dear. . . :

Events of recent years have brought into clearer perspective the social responsibility of engineering.

In respect of wise use of natural resources such reports as those of the Mississippi Valley Committee, the National Resources Committee and the Great Plains Drought Area Committee have brought out the facts impressively. The enclosed report, "Little Waters," presents in miniature many of the social-engineering problems of soil and water conservation.

In respect of the impact of science and engineering upon human life—social and economic dislocations as well as advance in productive power—the facts are revealed with distressing clearness in public records of unemployment, bankruptcies and relief. The responsibility of scientists has been analyzed in noteworthy addresses such as, among the most recent, those presented at the Tercentary Celebration of Harvard University and the meeting of the British Association for the Advancement of Science.

The design and construction of specific civil engineering works or of instruments for production represent only one part of the responsibility of engineering. It must also consider social processes and problems, and must coöperate, in designing accommodating mechanisms to absorb the shocks of the impact of science.

This raises the question whether the curricula of engineering schools are so balanced as to give coming generations of engineers the vision and flexible technical capacity necessary to meet the full range of engineering responsibility.

I am calling this matter to the attention of educators of high administrative authority in the hope that it may be thoroughly explored in faculty discussions and in meetings of engineering, educational and other pertinent professional associations.

Sincerely yours,

(signed) FRANKLIN D. ROOSEVELT.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

October 27, 1936.

Dear Mr. President:

The press release of your letter transmitting the conservation pamphlet "Little Waters" to engineering educators expresses the hope that there may be discussions in meetings of faculties and of educational and engineering associations as to whether curricula of engineering schools are so balanced as to give coming generations of engineers the vision and flexible technical capacity necessary to meet the full range of engineering responsibility.

I would respectfully call attention to the fact that during the past dozen years engineering educators have given extended attention to the problem of the development of the social and economic elements in the education of engineering students, and to the better coördination of engineering education with the social order in which engineers function. During this period there has been a clearly discernible trend toward the broadening and enrichment of engineering curricula with greater emphasis upon economics and the social sciences as well as upon scientific and technological fundamentals rather than upon technical specialties. This was one of the basic recommendations that resulted from the general survey of engineering education made during the years 1924 to 1929 by the Society for the Promotion of Engineering Education, and has also been reflected by numerous papers and discussions presented before national and regional meetings of this Society. Your letter conveys the impression that engineering educators are not duly or sufficiently conscious of the broad social implications of their work. Such, I believe, is not the case. If their view in this connection could be expressed in a sentence, I think it might be put about as follows:

Recognizing the benefits that can accrue to society through scientific and technological progress, teachers of engineering aim, without sacrificing the inherent values of the disciplines of a professional education, to orient their students toward the social significances of these advancements, as well as to train them in the technique of their accomplishments.

I further believe that within the limitations that inhere in an academic institution, particularly as to those elements of engineering curricula that are less susceptible of objective treatment than are sciences and technology, engineering educators are working purposefully to accomplish this aim.

Respectfully and sincerely yours,

(signed) H. P. HAMMOND, *President.*

COLLEGE HURDLES

By R. L. SACKETT

Dean, School of Engineering, Pennsylvania State College

There is every evidence of an increasing number of applicants for admission to engineering education, and it is reasonable to expect that it will continue, as it has in the past, to enlarge during the period of industrial expansion. More reasons conspire to make the prophecy almost a certainty. Keener competition, the success of scientific management in smaller industries, the developments of science which call for engineering application, the use of engineers in social and economic surveys, planning and execution, all point toward an increasing demand from new fields as well as a return of the old employers of young engineers to normal needs.

The present discussion seems to be more on the social content of courses than on the social content of the student. In other words it seems pertinent to emphasize the importance of student capacity, ambition, interests and aptitudes to the end that fewer may be called and more chosen, to paraphrase a Biblical injunction. How many of those who choose to take engineering promise a fair or good measure of success?

When the Investigation of Engineering Education was made in 1924–29, the report states that nearly 40 per cent failed to continue the second year. Scholastic failure accounted then for 54 per cent of those who did not return the following year; voluntary change of course for 15 per cent; finance, illness and other causes accounted for the remainder of the class which discontinued.

In 1934, the Engineers' Council for Professional Development gave the Coöperative Tests in English and Mathematics to 1900 students who entered eight engineering colleges and universities. In 1935 the same tests were given to nearly 3000 entering twelve institutions. At the end of the year the average of each student was received and the cause, if he did not continue. Charts were prepared for each institution showing the distribution of scores and grades and the scores in the tests of those who discontinued.

The mathematics test showed a favorable correlation of .57 with the average grade at the end of one year and of .52 at the end of the second year. It seems safe to say that a good mathematics test has selective value for engineering students.

The English test compared less favorably, giving a correlation coefficient of .45 when compared with the average grade at the end of one year and of .37 at the end of two years.

From the point of view of selection and vocational guidance, the most important facts revealed by the recent tests in 8 institutions in 1934 and 12 in 1935 is that the mortality during the first year has decreased from 39.4 per cent to 16.5 per cent—if this limited number of institutions is a safe guide. They represent large, medium sized and small enrollments, distributed over the United States, although the majority are from the East and North. At least the mortality can be reduced without lowering passing grades. In fact, it seems safe to say that grading is stricter, if anything. There has also been a measure of selection and better vocational guidance than was usual in 1924–29 which has helped to reduce the losses.

Another item worth mentioning is that in the Report of 1924–29 more students were dropped for poor scholarship than failed to return for other reasons. Recent data show the opposite. The Committee on Selection and Guidance asked that the causes for voluntary change or withdrawal be checked, viz., scholarship, illness, finance, dissatisfaction and miscellaneous. Scholarship and dissatisfaction account for too many who discontinued in engineering. Those who dropped out for these two reasons probably did not return later, while those who gave illness and finances as the reasons may have done so.

Guidance

The need for better selection and guidance should be emphasized again as it was in the Report. Too many students fail to continue because they did not have correct or sufficient information on which to make an intelligent choice. Some of the reasons given would be ludicrous if they were not so tragic. The student has not been led to test his interests or his aptitudes. He often does not have a clear objective. Incentives are lacking. One must make large allowance for immaturity, and guidance can never be perfect, but there is room and reason for improvement. Failure to continue is looked upon as a family embarrassment. The student who fails or is dissatisfied feels defeated, and his ambition may be killed. The economic loss to the institution is something, but the loss to individual ambition and perseverance is much more important. While the student who fails gets something out of his year or two—we hope—it is a weak excuse for failure to give him a sound basis on which to make a choice. The colleges should take and are taking a more serious part in vocational guidance.

Selection

Several state institutions are required to admit all applicants who have graduated from accepted high schools. Others make a selection on some basis which assists in deterring those who do not have the desired scholarship. Some institutions avoid embarrassment by such sound and intimate personal counsel that the less desirable ones go elsewhere. Several methods of selection of those who are better prepared to profit by an engineering education are in use, such as college entrance examinations and summer camp counseling, as is practiced by Stevens Institute of Technology, Worcester Polytechnic Institute and Lafayette College. Students who rank in the top two-fifths in scholarship during their four years high school record are accepted by The Pennsylvania State College without entrance examination, if they come from approved high schools and prep schools. Some schools are rated higher or lower according to experience with their graduates. Other institutions have pursued similar methods of selection, and they have proved to be effective both in encouraging certain high schools to raise their standards of quality and in pointing out to students that they are not well fitted for a technical education. Aptitude and training examinations are given to those of lower rank, and experience shows that a considerable proportion of them do not have the preparation and aptitude necessary for reasonable achievement in an engineering curriculum. For those who have been admitted and who show in their first year a doubtful progress, it is desirable that they be given some one of the interest tests, such as the Strong or Bernreuter in order to assist them to evaluate their interests and abilities.

With the prospective influx of engineering applicants, the facilities for first and second year instruction must be increased, or instruction will not be of the character which the school in self-defense should provide. Humanly speaking, it is better to pursue a common sense method of selection than to lower the standards of instruction.

The Committee on Selection and Guidance of the Engineers' Council for Professional Development is searching for other tests which may be given with a view to better selection. Visualization, or engineering imagination, is an extremely valuable quality desirable in the engineering prospect, but not the sole quality needed. It has been proved by extended analysis that the grade which a student obtains in descriptive geometry has a high correlation with his average for the first year and for four years. The correlation is about as high as is obtained by any test, and, therefore, may be accepted as important. There are a number of such tests,

but there is no agreement as yet on any one which may be given by those who are not expert in the technique of testing. The development of such a test which may be given to high school students will be an important addition to our proved test repertoire.

D. C. Jackson has pointed out that keenness in observation is a highly desirable quality in an engineering student, and an objective test which shows the clearness of the photographic image made on the mind by the relationship of objects may be of assistance in the selection of those who have this quality. The S. P. E. E. has the opportunity to test out various devices for establishing the presence of this quality of visualization and that of observation. By comparing the scores in tests having such qualities with average grades for the first year and for four years, there is an extensive field for contribution to selective tests, of which we need only a few, if they are basic and also valid.

THE M.K.S. SYSTEM OF GIORGI AS ADOPTED BY THE INTERNATIONAL ELECTROTECHNICAL COMMISSION (I. E. C.) IN JUNE, 1935

By ARTHUR E. KENNELLY

Professor Emeritus of Electrical Engineering, Harvard University and Massachusetts Institute of Technology

Purpose and Scope

The object of this paper is to present a report, from the historical standpoint, to the S. P. E. E. on the actions of the I. E. C. in regard to the adoption of the m.k.s. system of units, especially with reference to the use of the system in engineering education. The paper is also intended to be a sequel to the report, "Historical Outline of the Electrical Units," presented to the S. P. E. E. by the writer in 1928 and published in The Journal of Engineering Education, Vol. XIX, No. 3, November, 1928, pages 229–275. This latter paper will be referred to in the following pages as the author's "1928 S. P. E. E. paper."

I. E. C. Bellagio Meeting of 1927

At its meeting in Bellagio in 1927 [1] the I. E. C. received a proposal from the Italian National Committee to adopt a practical unit of magnetic flux Φ in the practical *ohm-volt-ampere* series of units with the magnitude 10^8 c.g.s. magnetic units (this quantity is sometimes called the "*volt-second*"); and also to assign to this new practical unit the name "*maxwell.*" After some discussion, in which much difference of opinion was manifested, the matter was left to a special international committee of seven members, representing the countries: France, Germany, Great Britain, Holland, Italy, Russia and the United States, for consideration and report. This committee took up the matter by correspondence. No consensus of opinion could be reached. In addition to the difficulty of shifting the name *maxwell* from one c.g.s. magnetic unit of flux Φ, as adopted in Paris in 1900, to 10^8 c.g.s. magnetic units, there was much debate in the committee as to the meanings of the unit names *maxwell* and *gauss.*

It was therefore recommended to the various I. E. C. National Committees to place the question on the docket for the next I. E. C. meeting (Scandinavia in 1930) and to agitate the question in ad-

vance in the various countries so as to pave the way for international decision in 1930.

I. E. C. Plenary Scandinavian Meeting of 1930

At the Scandinavian meeting in 1930 [4] the question of magnetic units was discussed in detail by the special subcommittee on Electric and Magnetic Magnitudes and Units (E. M. M. U.), with additional members. No international progress could be made until agreement could be reached on the question as to whether magnetic flux density B and magnetizing force H should be taken as physically identical quantities or not. It was finally unanimously agreed that for electrotechnical purposes B and H should be considered as different quantities so that their ratio in a vacuum $\mu_0 = B/H$, the absolute permeability of free space, should be considered as having physical dimensions, and not as a mere numeric. This agreement has been called the "Oslo convention." Opinions in text books on magnetics were found to differ on this question, but the convention was accepted as representing a majority opinion. Similarly, in a simple magnetic medium, the "absolute permeability" $\mu = B/H$ was accepted as likewise having physical dimensions. The "relative permeability" of the medium μ/μ_0 was accepted for electrotechnical purposes as a simple numeric.

After agreement had been reached on this convention, the following unit names were agreed to in the c.g.s. magnetic system of units:

The name *maxwell* for the c.g.s. unit of magnetic flux Φ.
The name *gauss* for the c.g.s. unit of magnetic flux density B.
The name *ærsted* for the c.g.s. unit of magnetic field strength H.
The name *gilbert* for the c.g.s. unit of magnetomotive force $\mathcal{F}$.

In the practical series of magnetic units the name *pramaxwell* was provisionally adopted as the name for a new practical unit of magnetic flux Φ, or 10^8 *maxwells*. The prefix "*pra*" was likewise provisionally adopted for the denomination of units in the practical system corresponding to units in the c.g.s. magnetic system. The unit name *ærsted* had already been used for some years in America to denote the c.g.s. magnetic unit of reluctance $\mathfrak{R}$, but had never been internationally adopted. It was changed at Oslo from reluctance $\mathfrak{R}$ to magnetic field strength H. These actions of the I. E. C. Subcommittee on Magnitudes and Units were approved at the plenary I. E. C. meeting in Oslo, July, 1930.

The above mentioned actions of the I. E. C. in Oslo, in 1930, soon gave rise to much discussion in the magnetic literature of various countries. The actions taken received some approval, but

considerable opposition. In view of the difference of opinion thus manifested in various countries, it was decided to hold a special meeting of the I. E. C., E. M. M. U. Committee in London, September, 1931.

E. M. M. U. (I. E. C.) Meeting in London, September, 1931

The E. M. M. U. Committee of the I. E. C. met in London, September, 1931, to consider the Oslo recommendations made by the same committee in July, 1930. Ten countries were represented by delegates. The President and Secretary of the S. U. N. committee attended the meeting, as well as Prof. H. Abraham (General Secretary of the I. P. U.), President Enström, and General Secretary LeMaistre of the I. E. C. At this meeting the actions taken at Oslo in regard to c.g.s. magnetic units were endorsed unanimously.[12]

Meeting of the International Union of Pure and Applied Physics (International Physical Union, I. P. U.), at Brussels, 1931

The International Union of Pure and Applied Physics at its meeting in Brussels in July, 1931, appointed a new committee on "Symbols, Units and Nomenclature" (S. U. N.), with Sir Richard Glazebrook as Chairman and Dr. E. Griffiths as Secretary. The I. E. C. requested the coöperation of the S. U. N. Committee at the London Meeting in September, 1931. A printed questionnaire was addressed to physicists and physical societies in many countries on the subject of "electrical units" and especially in relation to c.g.s. magnetic units. The document requested opinions and comments in relation to the actions taken by the I. E. C. in Oslo in 1930 on these units and their names.[14] The answers received by the S. U. N. Committee were subsequently published.

S. U. N. Meeting in Paris, July, 1932

In view of the International Electrical Congress in Paris, in July, 1932, with a large number of attendant electrical men from various countries, the S. U. N. Committee called an informal meeting on July 9, 1932, at Paris for the discussion of matters contained in the above mentioned questionnaire, and especially the c.g.s. magnetic units. Its President, Sir Richard Glazebrook, was the Chairman, and Dr. E. Griffiths was the Secretary; nineteen persons from eight countries attended. The actions taken were informal, in the sense that the voting was by individuals and not by countries. The resolutions adopted, if not unanimous, were by considerable majorities. Among these resolutions was the proposition (6 on the

docket): "*B* and *H* are quantities of different nature." The Oslo convention was endorsed, and the I. E. C. actions concerning c.g.s. magnetic units and their names were confirmed. No specific reference was made to the Giorgi system, but it was voted that: "(1) Any system of units recommended must retain the eight internationally recognized practical units: *joule, watt, coulomb, ampere, ohm, volt, farad, henry.*" It was voted also that in any practical magnetic system, "the factor $4\pi/10$ should be retained in the definition of magnetomotive force." This implies that the S. U. N. Committee opposed rationalizing the practical magnetic system.[22]

Eighth International Electrical Congress, Paris, July, 1932

This Congress was convened to mark the 50th Anniversary of the important first Congrés Internationale des Electriciens, held in Paris in 1881. Its President was M. Paul Janet. It was divided into thirteen sections, and listed in all 1318 members, representing thirty-five countries. The *Transactions* of the Congress were subsequently printed in thirteen volumes.

Individual papers presented at the Congress referred to electric and magnetic units.[15, 16] There were, however, no official discussions or actions taken by the Congress in relation to such units or their names.

Meeting of American Section I. P. U. at Chicago, in June, 1933

It had been intended to hold a meeting of the I. P. U. at Chicago contemporaneously with the Century of Progress Exposition of 1933, but it was decided to defer this meeting to some later date. A meeting of the American Section of the I. P. U. was, however, held at Mandel Hall, University of Chicago, June 24, 1933, with a few foreign guests present. The program was directed to the work of the International S. U. N. Committee and six papers were read, with E. C. Crittenden, Chairman of the American Section S. U. N. Committee, in the Chair. The papers related to magnetic units and systems.[26] Dr. R. A. Millikan, as President of the I. P. U., presided at the meeting, and Dr. E. Bennett acted as Secretary. The attendance was about one hundred and fifty, and of these the estimated number voting was thirty to forty. In brief, the following resolutions were passed:[26]

(1) That the classical c.g.s. systems should be left unchanged.

(2) That the existing series of practical units could advantageously be extended into a complete absolute practical system, either through the m.k.s. system, or through the c.g-s.s. system; of these, the m.k.s. is preferred.

(3) That the American S. U. N. Committee shall be requested to consider the objections to the use of the absolute *ohm*, and the advantage that might be gained by the use of the international *ohm* in the practical system.

Meeting of the E. M. M. U. (I. E. C.) Committee in Paris, October, 1933

This meeting was called to consider the actions taken by the preceding E. M. M. U. meeting in 1931, and also of the recent meetings of the S. U. N. Committee in relation to electric and magnetic units. The *weber* was adopted as the practical unit of magnetic flux Φ, subject to approval of the various national committees. The action on the prefix "*pra*" was rescinded, since the majority of the delegates disfavored its use. The names *hertz* and *siemens* were voted for the names of the practical units of frequency and conductance, respectively. The Oslo convention concerning μ_0 and μ was reconfirmed. Special consideration was given to the resolutions passed by the American Section of the I. P. U. at Chicago in June, 1933, as hereabove referred to, on the extension of the practical series of units into a complete system. Professor Giorgi, who was present as an Italian representative, gave a brief résumé of the m.k.s. system. Prof. H. Abraham, General Secretary of the I. P. U., who attended the meeting, pointed out certain advantages of the m.k.s. system, as also did M. Brylinski, President of the French I. E. C. National Committee. The following resolution was adopted unanimously:

"Section B of the advisory committee No. 1 on nomenclature, having heard with great interest the communication from Mr. Giorgi on the m.k.s. system, and endorsing the resolution adopted by the American Section of the International Physical Union, in June, 1933, decides to invite the national committees to give their opinion on the extension of the series of practical units at present employed in electrotechnics by its incorporation in a coherent system having as fundamental units of length, mass and time, the *meter, kilogram* and *second*, and as a fourth unit either that of resistance expressed as the precise multiple 10^9 of the c.g.s electromagnetic unit, or the corresponding value of the space permeability of a vacuum."

These resolutions were distributed to all the I. E. C. national committees in the regular way, together with the minutes of the meeting,[27] with a request for opinions.

Actions of the I. E. C. at its Plenary Meeting in Scheveningen-Brussels, June, 1935

In regard to actions on units, the E. M. M. U. Committee met at Scheveningen in June, 1935, with representatives from 15 countries.

President Enström attended the sessions. Professor Paul Janet, President of Advisory Committee No. 1, was prevented from being present. He was unanimously elected Honorary President of the I. E. C., an honor shared by Dr. Elihu Thomson. The principal actions taken at this meeting were briefly as follows:

1. The Oslo convention concerning μ_0 and μ was reconfirmed.

2. The adoption of the *weber* was confirmed as the name of the practical unit of magnetic flux Φ.

3. The replies were read as received from the various national committees concerning the extension of the practical series into a practical system of units, on the m.k.s. basis. No opposition was recorded. The question of adopting the m.k.s. system was then moved and unanimously approved, except that two countries made reservations as to the suitability of retaining the *kilogram* as a basis unit of the system.

There was considerable difference of opinion among the delegates as to the fourth fundamental unit for the system. The *ohm* and the *coulomb* each had been suggested. It was agreed that a fourth unit was needed, because it would be possible, starting with the three units, *meter, kilogram* and *second,* to construct a number of possible associated electromagnetic series, differing from the existing practical series which all desired to maintain. It finally was agreed to defer action on the choice of a fourth fundamental unit until an opportunity had been offered to consult the Comité Consultatif d'Electricité (C. C. d'E.) of the International Committee of Weights and Measures (I. C. W. and M.) at Sèvres, and also the S. U. N. Committee of the I. P. U. In the meantime, it was voted that the new system should be called the "Giorgi System." Opinions also were requested from the various national committees as to the selection of the fourth unit.

4. By way of example, in the formation of derived units in the system, the following were adopted unanimously: (*a*) the *volt per meter* as unit of electric force; (*b*) the *weber per square meter* as unit of magnetic flux density B; (*c*) the *joule per cubic meter* as unit of volume energy.*

5. The actions taken at the preceding meeting in Paris, concerning the practical unit names *hertz* and *siemens* were confirmed, as also the desirability of inserting the space permeability symbol μ_0 in all working magnetic formulae where its absence might mislead, thus reconfirming the Oslo convention.

* Thus the well known formula for induced e.m.f. in a flux-cutting wire ($e = Blv$) can only be expected to give a result in *volts* if systematic units are used; *i.e.*, B is in *webers/m.*^{2}, l is in *meters,* and v is in *meters/sec.,* but for purposes of description other units may be used; *e.g.*, l in *cm.* and v in *cm./sec.*

Outline of the Giorgi M.K.S. Practical Absolute System

In 1901 Professor G. Giorgi of Rome published his proposal for an absolute practical m.k.s. system of electrical and magnetic units, based on the *meter, kilogram* and *second* as fundamental units of length, mass, and time.* Giorgi contributed a paper to the *Transactions* of the International Electrical Congress in 1904 on the same subject.† He showed that all of the electromagnetic units in the practical series might be regarded as belonging to the m.k.s. system in the same way that the *dyne* and *erg* belong to the classical c.g.s. systems of Maxwell. Students of engineering could therefore receive their instruction in the m.k.s. system without necessarily studying the c.g.s. system itself, from which the practical units had been historically derived. The decimal numerical coefficients 10^1, 10^7, 10^8, and 10^9 could, therefore, be omitted from textbooks of engineering, leaving the c.g.s. systems undisturbed in their relations to physics and general science. No change was necessary in any of the practical *ohm-volt-ampere* series of units in order to fit them into the m.k.s. system, but the numerical value of magnetic space permeability μ_0 was changed from 1 in the c.g.s. magnetic system to $4\pi \cdot 10^{-7}$ in the Giorgi system (rationalized). Moreover, by taking the electric permittivity ϵ_0 at the numerical value of $8.854 \cdot 10^{-12}$ *farad/m.* (rationalized), all electrostatic phenomena could be dealt with directly through the practical electromagnetic units without having to use a separate electrostatic system. In other words, Giorgi expanded the practical series of eight internationally adopted practical units into a single complete absolute system, with no need for a parallel electrostatic system.

The following Table I gives a list of forty-eight units and their names in the fields of Mechanics, Energetics, Thermal, Luminous, Electric and Magnetic.

The last column (VI) gives the number of c.g.s. units in each m.k.s. unit. Thus, in quantity number 1, Length, the m.k.s. unit being the *meter*, contains 100 *centimeter* units of the c.g.s. system. This last column is explanatory only, and does not need to be memorized by the student. It will be seen that in the c.g.s. system, except for numbers 45 and 46, the unit names are impersonal; whereas in the m.k.s. system, eleven of the unit names are personal, or pertain to savants. It was the original intention of the framers of the c.g.s. system that c.g.s. unit names should be impersonal while the names of the practical units should be personal. A few exceptions to this rule were internationally adopted in later years

* See Bibliography 26 in author's 1928 S. P. E. E. paper.

† See Bibliography 36 in author's 1928 S. P. E. E. paper (*Trans.* El. Cong. St. Louis, 1904, Vol. 1, pp. 136–141).

TABLE I

INCOMPLETE LIST OF M.K.S. UNITS AND OF CORRESPONDING C.G.S. UNITS

No. I	Quantity II	Symbol III	M.k.s. Unit IV	C.g.s. Unit V	C.g.s.u. in One M.k.s.u. VI
			Mechanic		
1	Length	L	meter	centimeter	10^2
2	Mass	M	kilogram	gram	10^3
3	Time	T	second	second	1
4	Area	S	m.^{2}	cm.^{2}	10^4
5	Volume	V	m.^{3} (stere)	cm.^{3}	10^6
6	Frequency	f	hertz, cy./sec.	cy./sec.	1
7	Density	d	kg./m.^{3}	g./cm.^{3}	10^{-3}
8	Specific gravity		numeric	numeric	1
9	Velocity	v	m./sec.	cm./sec.	10^2
10	Slowness		sec./m.	sec./cm.	10^{-2}
11	Acceleration	a	m./sec.^{2}	cm./sec.^{2}	10^2
12	Force	F	——(joule/m.)	dyne	10^5
13	Pressure	p	——(joule/m.^{3})	dyne/cm.^{2}, barye	10
14	Angle	α, β	radian	radian	1
15	Angular velocity	ω	radian/sec.	radian/sec.	1
16	Torque	τ	——(joule/radian)	dyne $\perp$ cm.	10^7
17	Moment of inertia	J	kg. m.^{2}	g. cm.^{2}	10^7
			Energetics		
18	Work or energy	W	joule	erg	10^7
19	Angular work	W	joule	erg	10^7
20	Volume energy	w	joule/m.^{3}	erg/cm.^{3}	10
21	Active power	P	watt	erg/sec.	10^7
22	Reactive power	jQ	var.	erg/sec.	10^7
23	Vector power $P \pm jQ$		watt $\angle$	erg/sec.	10^7
			Thermal		
24	Quantity of heat	Q	kg. calorie	g. calorie	10^3
25	Temperature	θ	° C. or ° K.	° C. or ° K.	1
			Luminous		
26	Intensity	I	candle	candle	1
27	Luminous flux	Ψ	lumen	lumen	1
28	Illumination	E	lux	phot	10^{-4}
29	Brightness	b	candle/m.^{2}	stilb	10^{-4}
30	Focal power		diopter	——	10^{-2}

TABLE I (*Continued*).

No. I	Quantity II	Symbol III	M.k.s. Unit IV	C.g.s. Unit V	C.g.s.u. in One M.k.s.u. VI
			Electric		
31	Electromotive force	E	volt	——	10^8
32	Potential gradient	$\mathcal{E}$	volt/m.	——	10^6
33	Resistance	R	ohm	——	10^9
34	Resistivity	ρ	ohm m.	——	10^{11}
35	Conductance	G	siemens, mho	——	10^{-9}
36	Conductivity	γ	siemens/m. mho/m.	——	10^{-11}
37	Reactance	jX	ohm	——	10^9
38	Impedance $R \pm jX$	Z	ohm $\angle$	——	10^9
39	Quantity	Q	coulomb	——	10^{-1}
40	Displacement	Q	coulomb	——	10^{-1}
41	Current	I	ampere	——	10^{-1}
42	Current density	i	ampere/m.^{2}	——	10^{-5}
43	Capacitance	C	farad	——	10^{-9}
44	Spec. in. capacity	ϵ/ϵ_0	numeric	numeric	1
			Magnetic		
45	Magnetic flux	Φ	weber	maxwell	10^8
46	Flux density	B	weber/m.^{2}	gauss	10^4
47	Inductance	L	henry	——	10^9
48	Rel. permeability	μ/μ_0	numeric	numeric	1

Note: Various units used in acoustical engineering, radio engineering and mechanical engineering are omitted from this list.

(*gilbert, œrsted, maxwell* and *gauss*) owing to the action of the Chicago Congress of 1893, which decided that working magnetic units should be kept in the c.g.s. system and not adopted in the practical system. Consequently, it would seem consistent to have new c.g.s. unit names in the future impersonal, and new m.k.s. unit names in the future personal, in order to distinguish more plainly between the two systems.

Mechanics

Numbers 1 and 2 of Table I are the international *meter* and the international *kilogram*, according to the primary standards maintained at the International Bureau of Weights and Measures at Sèvres, near Paris. Number 3 is the mean solar *second*, as maintained by the International Astronomical Union, as in the c.g.s. system. This is also incidently maintained at Sèvres by standard clocks. Numbers 4 and 5 are obtained directly from the interna-

tional *meter*. Number 6, *hertz*, was adopted by the I. E. C. in 1935, by a majority vote and not unanimously, so that the unit names *cy./sec.* or *period/sec.* are permissible. Number 7 shows that the m.k.s. unit of density is 1000 times smaller than that of distilled water under standard specifications. The m.k.s. density of water is thus 1000. Number 8, specific gravity (density of material/density of water), is, however, the same in the m.k.s. as in the c.g.s. systems. Number 12, m.k.s. unit of force, may be called the *joule/meter* because when exerted uniformly through a distance of 1 *meter* this force does work equal to 1 *joule*. The name "*vis*" has been suggested for this m.k.s. unit of force, but a personal name would seem to be preferable. The names "*newton*" and "*gal*" or "*galeo*" (for Galileo) have been suggested. The *joule/meter* may be defined dynamically as the force which, acting uniformly on a free *kilogram* of matter, gives it an acceleration of 1 *m./sec.*^{2}, relatively to its environment (Number 11). This is roughly the weight of 100 *grams* (or more nearly 102 *grams*). This is a convenient magnitude of force unit for the purposes of mechanical engineering, being neither very small nor very large. This unit of force is also that exerted upon 1 *meter* of wire carrying steadily 1 *ampere* when supported perpendicularly across unit m.k.s. magnetic field; *i.e.*, 1 *weber/m.*^{2} Number 13, m.k.s. unit of presure, is the *joule/m.*^{3}, or, in c.g.s. measure, 10 *dynes/cm.*^{2} This is only a feeble mechanical pressure, being 1/100,000 of normal atmospheric pressure, so that some decimal multiple of the unit would naturally be employed for most engineering purposes. A personal name for this unit might advantageously receive international adoption at some future time. Number 16, m.k.s. unit of torque, or *joule/radian*, is the unit of force exerted perpendicularly at a lever arm of 1 *meter* from the axis, and is of satisfactory magnitude for mechanical engineering purposes. Number 17, m.k.s. unit of moment of inertia, is that of 1 *kg.* situated at 1 *meter* from the axis of reference, and has also satisfactory practical size.

The m.k.s. units in the remainder of Table I may be regarded as self-explanatory.

Rationalized Versus Unrationalized M.K.S. Units

It was pointed out by Oliver Heaviside about the year 1881 * that the c.g.s. systems of units could be simplified in their application if electric and magnetic forces, instead of being standardized as diverging spherically from point charges and point poles, could be changed to standard rectangular distributions, such as are found in plane condensers and magnetic fields between opposed plane

* See Bibliography 22 of author's 1928 S. P. E. E. paper.

parallel poles. The electric and magnetic unit systems so modified he named "rationalized," as compared with the classical "unrationalized" systems already in existence. In classical unit systems a unit electric charge emits 4π units of electric flux, and a unit magnetic pole, 4π units of magnetic flux; whereas in a "rationalized" system unit electric charge would emit unit electric flux and unit magnetic pole, unit magnetic flux. The particular method, however, which Heaviside proposed for converting c.g.s. magnetic units from classical to rationalized types required changing the accepted international practical standards by awkward numerical factors involving $4\ \pi$. This would have called for sudden changes in the standard *ohm, volt,* etc., which would doubtless have caused great confusion. It was subsequently shown, however, by several writers, that the benefits of rationalization could be brought about without making any changes in the existing practical unit standards. Rationalized c.g.s. units have since been introduced by various writers of physics, employing the Heaviside-Lorenz c.g.s. system, without thereby disturbing the classical and unrationalized c.g.s. systems of Maxwell. The m.k.s. system, as recommended by Giorgi, is rationalized by making the unit of magnetomotive force (Table II, Number 54) equal to one *ampere-turn,* instead of the 4πth part of an *ampere-turn,* with the corresponding modified numerical values for magnetic permeability μ_0 and electric permittivity ϵ_0. There has, however, been much difference of opinion among teachers and students of both physics and engineering as to the desirability of rationalization. The S. U. N. Committee in its meetings has shown a majority in favor of keeping the m.k.s. system in the classical, or unrationalized, form; while in the meetings of the I. E. C., E. M. M. U. Committee a slight majority has favored rationalizing the m.k.s. system. It seems evident that any attempt to decide this question at the present time by international vote would divide workers in the m.k.s. system into two opposing groups, the rationalists and the non-rationalists, which would probably stand in the way of progress in the study and use of the m.k.s. system. It has, therefore, been considered desirable by the I. E. C. to leave the question of rationalization open and undecided for the present, until international opinion may become definitely settled one way or the other. It is at present optional for a writer to use either form of the m.k.s. system, assuming that his choice is clearly specified. A similar condition already exists in the literature of physical science with regard to c.g.s. systems.

Tables II and III list electric and magnetic units which are affected by the question of rationalization. Rationalization may be considered as not entering into the forty-eight units of Table I.

TABLE II

LIST OF ELECTRIC AND MAGNETIC M.K.S. UNITS AFFECTED BY THE DEFERRED QUESTION OF RATIONALIZATION

No.	Quantity	Symbol	Name of M.k.s. Unit		No. of Unrat. U. in One Rat. U.
			Rationalized	Unrationalized	
		Electric			
49	Electric flux	Ψ	coulomb	——	
50	Flux density	D	coulomb/m.^{2}	——	
51	Space permittivity	ϵ_0	farad/m.	——	
52	Space elastivity	σ_0	m./farad	——	
53	Elastance	S	daraf	——	
		Magnetic			
54	Magnetomotive force	$\mathfrak{F}$ or M	ampere-turn	——	4π
55	Magnetizing force	H	amp.-turn/m.	——	4π
56	Space permeability	μ_0	henry/m.	——	$1/4\pi$
57	Space reluctivity	ν_0	m./henry	——	4π
58	Permeance	$\mathcal{P}$	weber/amp.-turn	——	$1/4\pi$
59	Reluctance	$\mathcal{R}$	amp.-turn/weber	——	4π
60	Pole strength	m	weber	——	$1/4\pi$
61	Magnetic moment (ml)	$\mathfrak{M}$	weber m.	——	$1/4\pi$
62	Magnetization	$\mathfrak{J}$	weber/m.^{2}	——	$1/4\pi$

TABLE III

NUMERICAL VALUES OF SPACE CONSTANTS IN M.K.S. SYSTEM, RATIONALIZED AND UNRATIONALIZED

No.	Quantity	Symbol	Rationalized	Unrationalized
		Electric		
51	Permittivity	ϵ_0	$10^7/4\pi c^2 = 8.854 \times 10^{-12}$	$10^7/c^2 = 1.113 \times 10^{-10}$
52	Elastivity	σ_0	$4\pi c^2/10^7 = 1.129 \times 10^{11}$	$c^2/10^7 = 8.988 \times 10^9$
		Magnetic		
56	Permeability	μ_0	$4\pi \times 10^{-7} = 1.257 \times 10^{-6}$	10^{-7}
57	Reluctivity	ν_0	$10^7/4\pi = 0.7958 \times 10^6$	10^7

The value of the transmission velocity c is here taken as 2.998×10^8 m./sec., and of c^2 as 8.988×10^{16} (m./sec.)^2.

It is generally admitted that rationalization increases the simplicity and coherence of the m.k.s. system, but it introduces deviations in various electric and magnetic formulæ from those of the classical c.g.s. systems of Maxwell. Unit names are available, as shown in Table II, for nearly all the electric and magnetic m.k.s. units in the rationalized form, although some of these names are cumbersome; whereas many unit names are needed internationally for corresponding m.k.s. units in the unrationalized form.

A textbook employing units of the m.k.s. system (rationalized) has recently been published in Great Britain.[39]

Opinions Received on the Fourth Basic M.K.S. Unit

The Comité Consultatif d'Electricité of the I. C. W. and M. met in Paris, October, 1935, under the chairmanship of Professor Paul Janet. It considered and communicated to the I. C. W. and M. a report upon the question proposed by the I. E. C. This report has already been published.[33, 34] In brief, the C. C. d'E. recommended that magnetic space permeability μ_0 taken as 10^{-7} (unrationalized) or $4\pi \cdot 10^{-7}$ (rationalized), should be regarded as the best link between the m.k.s. dynamical and the internationally adopted electromagnetic units; and also that all of the practical electromagnetic units were equally involved in the Giorgi system. The *ampere*, as the practical unit of current, *I*, might be considered as the most suitable representative to serve as a fourth basic unit. The *ohm*, as the unit of resistance, *R*, in the practical absolute system, was considered as perhaps the next best representative. The absolute practical *ampere* should be considered as 1/10th of the c.g.s magnetic unit of current, and the absolute practical *ohm* as exactly 10^9 c.g.s. magnetic units.

The report of the S. U. N. Committee of the I. P. U. is appended to this paper. It has not heretofore been published. The report is signed by the Chairman, Sir Richard Glazebrook, F.R.S., the eminent British physicist, who was for many years Director of the National Physical Laboratory at Teddington. This report was probably his last official act, his death having followed very shortly afterwards. Briefly, the report recommends that the fourth basic unit of the m.k.s. system be space permeability μ_0, taken as either 10^{-7}, or $4\pi \cdot 10^{-7}$ *henry/meter*, according to rationalization. It was pointed out that the absolute practical units in the m.k.s. system may be rigorously defined as exact decimal multiples of the corresponding c.g.s. magnetic units.

The above opinions expressed by the courtesy of these two leading scientific organizations are, therefore, in agreement that a fourth unit is theoretically necessary to link internationally adopted

electrical units with the dynamical units of the m.k.s. system. They agree that this fourth unit may preferably be space permeability, taken at the definite numerical value of 10^{-7} (unrationalized). They also agree that all of the internationally adopted electrical units should collectively be included in the Giorgi system, although some one of them might be employed for the fourth unit as a representative of the class.

If, therefore, the Giorgi system were to be designated in symbols as a four-unit system, the following groups of four symbols might be employed: M.K.S.μ_0, M.K.S.I., or M.K.S.Ω. Doubts have been expressed, however, as to the benefit of any four-symbol title. The three-symbol title, M.K.S., might be simpler and less ambiguous than any four-symbol title, provided that μ_0, I or Ω were definitely referred to in the text of the specifications for the Giorgi system.

The I. C. W. and M. at Sèvres has received definite instructions to abrogate the international electrical standards adopted at Chicago in 1893 and to replace them by new standards embodying as nearly as possible the absolute practical units, with the aid of the various national physical laboratories. Under these conditions the electrical units of the Giorgi m.k.s. system will thus be theoretically the absolute practical units, exact decimal multiples of the c.g.s. magnetic units, but, practically, replicas of the standards maintained at Sèvres. If, at any future time, the I. C. W. and M. should decide to fix and stereotype the electrical unit standards, just as the meter and kilogram have already been fixed, the standards of the m.k.s. system would, doubtless, continue to be replicas of the Sèvres primary standards, which would be the same for both physics and electrotechnics. Thereafter, any small residual departures of the Sèvres primary standards from the precise decimal multiples of the c.g.s. magnetic units might involve small changes in the conventional values of μ_0 or ϵ_0 without involving any change of the basis of the m.k.s. system.

These questions remain to be decided by the I. E. C. at a future meeting.

APPENDIX

Report of the S. U. N. Committee

Reply from the S. U. N. Commission of the International Union of Pure and Applied Physics to the request for advice on the choice of the "fourth unit" of the Giorgi System of Units, contained in a letter dated 27th June 1935, to Professor Abraham, Secretary of the International Union, from Professor Kennelly, Chairman of the E. M. M. U. Committee of the I. E. C.

The S. U. N. Commission has given very careful consideration to the request of the I. E. C. for help in the selection of the fourth quantity

which, in the view of the I. E. C., is required to complete the M.K.S. system of units and desires to thank the I. E. C. for referring the question to the Commission.

The Table which accompanies this reply has been prepared to show the relation between some of the quantities concerned in the M.K.S. and C.G.S. systems respectively.

The Commission has consulted a large number of leading Physicists and, with hardly any exception, the following resolution, proposed by Dr. Abraham, Secretary of the International Union of Pure and Applied Physics, has been approved.

"Considérant que lors de leur création les unités électromagnétiques du système pratique avaient été définis comme étant des multiples décimaux exacts des unités électromagnétiques C.G.S.

"Considérant que ces définitions initiales comportent plus de précision expérimentales et plus de securité que des définitions basées soit sur la conservation de certains étalons soit sur des techniques spéciales (colonnes de mercure, électrolyse).

"La Commission émet l'avis:

"Il n'y à pas lieu de modifier les définitions initiales des unités électriques du système pratique, définitions qui fixent pour ces unités des valeurs égales à des multiples décimaux exacts des unités du système C.G.S. électromagnétique."

The Commission is pleased to learn from a letter * from Professor Marchant that at the I. E. C. meeting, although there is nothing in the Minutes stating that the basis of the decision should be that the permeability of free space should be taken as unity, the reason why the question of the fourth unit was referred to the two Committees concerned was that the Commission was anxious that whatever was chosen should be consistent with the C.G.S. system of units.

The Table gives effect to this view.

The S. U. N. Commission therefore recommends:

That the Table appended to this Report be accepted generally as defining the relation between the C.G.S. and the M.K.S. System of Units.

The accepted system of electrical measurements is based on the Reports of the British Association Committees on Standards for Electrical Measurements, 1861–1870, 1880–1912. The Committee in 1863 decided to employ the "absolute" system of measurement which they explained in the following terms.

"The word 'absolute' in the present sense is used as opposed to the word 'relative' and by no means implies that the measurement is accurately made or that the unit implied is of perfect construction; in other words, it does not mean that the measurements or units are absolutely correct but only that the measurement instead of being a simple comparison with an arbitrary standard of the same kind as that measured is made by reference to certain fundamental units of another kind treated as postulates."

The fundamental units selected were those of length, mass and time. For the construction of standards of measurement the knowledge is required of the forces between electrical and magnetic quantities expressed

* "Nature," p. 110, July 20, 1935.

in these fundamental units. Theory shows that, under the conditions assumed by Maxwell, one additional quantity is necessary, and is sufficient, to give us that knowledge. Theory also shows that this quantity, usually denoted by the symbol μ_0 is a measure of the "permeability," the ratio, that is, of magnetic induction to magnetizing force, in "free space" the medium in which the measurements are supposed to be made.

On the C.G.S. system the value of μ_0 is assumed to be unity.

The M.K.S. system can be made absolute by the assumption of any convenient value for μ_0 but, if the units of that system are to be the practical units of the C.G.S. system, the value * of μ_0 must be 10^{-7}.

In reply therefore to the request from the I. E. C. the S. U. N. Commission recommends:

*That the "fourth unit" on the M.K.S. system be 10^{-7} Henry per Metre, the value * assigned on that system to the permeability of space.*

TABLE SHOWING THE RELATION BETWEEN QUANTITIES ON THE C.G.S. ELECTROMAGNETIC SYSTEM AND ON THE PROPOSED M.K.S. SYSTEM

	Length	Mass	Time	Magnetic Coefficient μ_0	Electromagnetic Coefficient A	Space Permeability μ_0/A	Coulomb	Ampere	Volt	Ohm
C.G.S.	1 cm.	1 gramme	1 second	1	1	1	10^{-1}	10^{-1}	10^{8}	10^{9}
M.K.S.	1 metre.	1 kilogramme	1 second	10^{-7}	1	10^{-7}	1	1	1	1

On a modern "Maxwell" theory of Electricity the permeability of space, which is measured by the ratio μ_0/A, is assumed to be a quantity having dimensions. Its value, therefore, will depend on the system of units employed. On the C.G.S. system the permeability of space has been selected as the unit of permeability. Hence on this system, since $A = 1$, the value of μ_0 is unity. On the M.K.S. system the value of μ_0 is 10^{-7}, and on the "rationalized" M.K.S. system it is $4\pi \times 10^{-7}$.

At the same time the S.U.N. Commission desires to take this opportunity of placing on record their recognition of the fact that there are important electrical theories supported by a number of Physicists in accordance with which $A = c$ the velocity of wave propagation and $\mu_0 k_0$ is a pure number.

(Signed) R. T. GLAZEBROOK,
President of the S. U. N. Commission of the International Union of Pure and Applied Physics

30th November, 1935

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TWELVE YEARS OF EXPERIENCE IN TRAINING THE ENGINEERING-PHYSICIST *

By HOMER L. DODGE

Director of the School of Engineering Physics, University of Oklahoma

In *The Next Hundred Years—The Unfinished Business of Science*, by C. C. Furnas, Associate Professor of Chemical Engineering at Yale University, there is a chapter called "The Scholar's Haven." I recommend it to all professors of physics. It is *provocative*, but in a somewhat different sense of the word from that employed last year by Professor Elliott when he began and ended his excellent paper on "The Aims and Objectives of Physics in an Engineering School" by saying that it was intended to be *provocative*. Our chemistry friend at Yale intends really to *provoke* us. He says:

"Physics is a subject for scholars. All others are barred because of incompetence. If a subject is 'practical,' that to many scholars is a necessary and sufficient reason to be averse to it. Physics is just as widespread and as far-reaching as chemistry but the membership of the American Physical Society is only about one-eighth of that of the American Chemical Society, yet there is just as much physics to be done as chemistry. . . .

"Because of this rather sanctimonious attitude of the physicists, for which no one in particular is to blame, there are a great many people doing physicists' work but passing under another name—electrical engineers principally, but also mechanical engineers, physical chemists, astronomers, chemical engineers, geologists, and occasionally even civil engineers. It really makes no difference about names as long as the work is done, but there are some fields that have suffered because of the scholarly isolationist policies of the physicists. . . .

"The pure physicist too often has a noticeable attitude of contempt for anything that might by any chance ever be 'practical.' This snobbish attitude is expected of a classicist but it is a little hard to believe that it is becoming to a scientist. There are many exceptions to this indictment for which apologies should be offered, but by and large the accusation holds. The quest for human knowledge should not be confined to 'practical' subjects, not by any means, but neither should practicality exclude a subject from consideration."

It is interesting to us physicists to see ourselves as we appear to our friend in the field of chemistry. Whether or not he is right, I

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shall leave to each of you to decide, but I am prepared to say this: Because we believed that physicists trained with something of the engineering point of view and with courses in engineering would find a useful place in industry, the department of physics at the University of Oklahoma organized in 1924 a curriculum in engineering physics.

Due to the fact that our College of Engineering is made up of "schools," the approval of this curriculum by the faculty of the Engineering College carried with it the creation of a School of Engineering Physics coördinate with the Schools of Civil Engineering, Electrical Engineering, Chemical Engineering, etc. In the same way that the curriculum in electrical engineering was made up of courses not only in what might be called the department of electrical engineering but also in several other branches as well, the curriculum in Engineering Physics was made up of courses in physics and in engineering which already existed. In other words, the School of Engineering Physics needed to be no more than a "paper school." Since 1924, a few changes have been made in the curriculum, principally in order to give more freedom of election. It is now possible by a proper selection of courses to have what amounts to a major in geophysics.

These changes have not, however, required the addition of any appreciable number of courses. Moreover, the administration of the curriculum or "School" is exceedingly simple. What I am really saying is that the cost of this program is nothing. In any institution where there is an engineering school and a strong department of physics, the cost of financing a curriculum in applied physics would be small. Accordingly, in these institutions it is merely a question of whether the results are desirable.

In the case of liberal arts colleges that are not associated with engineering colleges, the problem is a different one; for here the typical engineering courses are not available. In the case of engineering schools devoted primarily to the older branches of engineering and to the newer branches which seem to fit into the traditions of engineering, frequently the physics department is merely a service department, there being no genuine appreciation of the place of physics in the engineering picture.

Let us keep these different typical situations in mind while we consider the large institution with a well developed physics department and an engineering school. Here we have the stage set for whatever action we choose. Until about fifteen years ago, the physics department, in the larger institutions (to speak in broad terms), was devoting itself to two things: one, a rather unimaginative teaching of traditional physics in the required elementary courses; the other, the pursuit of research, with the accompanying

graduate work. This is not hard to understand; for, although I am not old enough to know from personal experience how difficult the struggle was to develop the spirit of research in this country, I have heard the story from an older generation and know that a good deal can be said for the restriction of the interests of the American Physical Society to the one purpose of promoting research. And yet the American Physical Society might well have more actively encouraged the various attempts that were made from time to time to emphasize other important phases of the physics picture.

It is strange that in these large departments where the staff found their own personal satisfaction in making of physics a "live" subject for themselves through their active participation in research, so little of this spirit trickled down to the elementary work, which was too frequently regarded as drudgery to be disposed of as quickly as possible or to be relegated to members of the staff regarded as less worthy than those proficient in research. That this is not an exaggerated picture is indicated by the fact that the intermediate and advanced courses in these large departments of physics were usually taken by a noticeably small number of students, with few of the elementary students interested in further study of physics. The graduate student group was recruited largely from the better, smaller colleges where frequently were to be found professors of physics who gave their students a genuine understanding of the significance of the subject and the possibilities which it offered as a career.

At the University of Oklahoma, we have been attempting as best we can to develop a full, rounded program. In 1919 there was an entirely new staff consisting of two men. A general physics course, taken largely by premedics, and a course for engineering students were offered. Except for the class in electrical measurements, made up principally of electrical engineers, there was little advanced work. Both members of the staff were aware of the situation referred to in the preceding paragraph, and we were both interested in the development of a strong undergraduate major program upon which to build our graduate work. To accomplish this, we proposed to teach the elementary courses not as a dry presentation of accumulated knowledge, but rather as an introduction to a live subject, vital in itself, of profound significance in its relation to the other sciences and essential to an understanding of the world about us. The results were phenomenal in that the demands for further undergraduate work, and later for graduate work, were so great that the department experienced a very rapid expansion. I mention these facts to indicate that our department tried to be alert to all the obligations and legitimate possibilities in our situation.

One development was somewhat embarrassing. Each year several students who had enrolled in engineering transferred to a physics major in the College of Arts and Sciences. We realized that what these men really wanted was engineering *and* physics. Why should they have to come to a liberal arts college to get the physics? The answer was the establishment within the College of Engineering of a "paper" School of Engineering Physics with a four-year curriculum made up of courses already offered in the various departments of the University.

As we look back over the twelve years of experience which we have had, we are not disappointed with the results. We did not expect large numbers.* All that we proposed to do was to furnish an opportunity for those young men who were driven by their own inclinations into the program.

With the individual student, the exact curriculum followed is not as important as the spirit in the department of physics. It is really not very important whether or not a man, when he completes his work, falls within the engineering physics classification. It is important, however, to have this curriculum as an expression of our attitude and of the attitude of the faculty of the engineering college. As a matter of fact, we have had engineering students change to a major in physics in the College of Arts and Sciences and graduate with more emphasis upon the standard engineering subjects than there would have been if the engineering physics student had taken the minimum of traditional engineering subjects and emphasized mathematics, chemistry, and languages. In fact, two men who are distinctly engineering physicists were graduated before the program was established. One, who received the M.S. degree in 1923, was placed in the United States Bureau of Standards. A year later, another man who had received the degrees of B.A. in 1920 and B.S. in E.E. in 1921, received the master's degree in physics. His thesis dealt with short electromagnetic waves and this proved fortunate, for, on becoming an "engineering physicist" in the Bell Telephone Laboratories, he soon found himself among the small group of men who developed the circuits for short-wave trans-Atlantic telephony and for ship-to-shore talk.

The first students who were definitely listed as having majors in engineering physics received degrees in 1927. One of them received the degree of B.S. in Engineering Physics and is engaged in geophysical prospecting for petroleum. The other, who held the degree of B.S. in E.E., received the degree of Master of Science in Engineering with a major in Engineering Physics and is en-

* Fourteen students were enrolled in the engineering physics curriculum in 1935–36.

gaged in the development of communication and X-ray equipment. Since that time, an average of six or seven students each year have finished a program which was a preparation for work in applied physics, although many of these began the program too late to qualify for a degree specifically in engineering physics.

Except at enrollment time the members of the staff are hardly aware of whether or not a man is definitely enrolled in engineering physics. We have a general idea as to the kind of career he is looking forward to and attempt to give him the preparation best adapted to his needs. This state of unawareness of the particular pigeon hole in which a man classifies is a healthy sign, for it means that our program in engineering physics is really an atmosphere pervading the department and is not merely a curriculum.

Our experience has demonstrated that all of the phases of the work of the department have prospered because of a balanced interest on the part of the staff in the different aspects of our work. We try to keep in mind that the elementary courses serve a multitude of purposes and that the majority of the students in our advanced undergraduate courses are not physics majors. Of those whose major interest is physics, some will teach, and some will go into research in what might be called pure physics, usually combined with teaching. Others, and these are the ones we are concerned with today, will go into the various fields of applied physics—some to do important industrial research, some to become heads of geophysical prospecting companies, and others to occupy more humble places. In all cases, we have tried to fit the training to their needs.

Judging from our experience, it is important from every standpoint that departments of physics should be consciously preparing men (and women) for industrial work. We are not alone in this attitude, for already a dozen or more departments are doing this very thing. The essential feature of such a program is not material. It is not a question of equipment or laboratory facilities. The one essential requirement is a sympathetic attitude toward the program on the part of all members of the physics staff and a genuine interest on the part of those immediately responsible for it. This interest must express itself not only in the organization of a suitable curriculum, so that the students may be properly fitted for positions in applied physics, but also in the establishment of such connections with employers that graduates may find their way to suitable positions. To create a situation in which potential employers will be eager to secure physicists will require more than the efforts of scattered departments, no matter how effective they may be in special cases.

There must be a national program devoted to showing industrialists how badly they need the services which physicists can render.

If physicists are to find a place in industry, it must come through the desire of industrialists to have them. Most industrialists are not aware of the fact that physicists can help them—that they can do things which no one else can do, and can do better some of the things that others attempt to do. This is not entirely the industrialists' fault; for, as soon as physics gets out of its purer forms, it takes on some other name and becomes electrical engineering or communication engineering or acoustical engineering. No one can measure the injury to physics resulting from its continual separation into branches under distinctive names. This has never been permitted in chemistry. There are physical chemists, organic chemists, metallurgical chemists, and the chemical engineer, with the emphasis always on "chemistry" and "chemist." On the other hand, whoever heard of a man calling himself an electrical physicist, or a radio physicist, or a mechanical physicist? It is true that the words "physics" and "physicist" and "physical" do not lend themselves to euphonic combinations, but this does not explain why such men as Jewett and the late Dr. Arnold of the Bell Telephone Laboratories, whose training and background were principally in physics, have permitted themselves to be described to college students by their own company-lecturers as electrical engineers, giving the entirely wrong impression that the training-route by which men attain to their type of work is through the typical engineering course.

Six years ago at the celebration of the Thirtieth Anniversary of the Founding of the Graduate College at the State University of Iowa, in a paper on "The Future of Physics," I made the following statement:

"In the opinion of many, the American Physical Society has never interested itself to a sufficient extent in aspects of physics other than those of pure science. Partly as a consequence of this aloofness there has been a setting up of barriers against the various fields of application instead of a pushing back of the fences to include under the influence of the central organization all who can profit by association with it and, in turn, lend their support to pure physics."

Not on account of these remarks, but because of the recognition on the part of many persons of the situation which caused me to make these remarks, there was organized shortly afterward the American Institute of Physics, whose function is to act as an integrating force in physics and to strive in every possible way to have the science of physics serve American life with all the fullness that we know to be within its capacity. As you all know,

one of the major activities of the Institute is the promotion of interest in applied physics on the part of industrialists as well as teachers of physics.

An Advisory Council on Applied Physics, made up largely of industrialists, has been organized under the auspices of the Institute. Next fall this Council and the founder societies of the Institute will join in a Symposium on Industrial Physics to be held in New York City in October. The meeting promises to be of great significance.

To return, in closing, to *our* part of this problem of making physics available to industry, let me summarize my remarks as follows:

(1) As physicists, we must become interested in all phases of our subject. We must be eager to give a proper place to the training of men for the industries—not in our own preconceived way, but in the way that is found to best fit them for their jobs.

(2) We must independently, and in coöperation with the American Institute of Physics, make every effort to let industrialists know how useful engineering physicists can be to them.

(3) We must work out our relationships to the engineering colleges in the various institutions where we find ourselves so that engineering physics may take its place as a recognized branch and have all the advantages which will come from a definite place in the engineering group.

To accomplish this last will require tact on the part of departments organized outside of engineering colleges; and tact, courage, and insistence on the part of departments now organized within engineering colleges and regarded solely as service departments like English and mathematics.

SHOULD ENGINEERING CURRICULA BE LENGTHENED?

By G. M. BUTLER

Dean, College of Mines and Engineering, University of Arizona

Introductory Statement

Your speaker graduated in four years from a curriculum in mining engineering that was so heavy that it was equivalent to over 150 standard semester units. In fact, the graduation requirements were so onerous that the professional degree of Engineer of Mines was conferred upon the graduates instead of Bachelor of Science. No courses in English, foreign languages, history, or economics were required, and no such courses were offered. Indeed, no electives were permitted.

Not once while in college was it even suggested by his instructors that he needed and should have training for citizenship, that it was even more important to become a good citizen than to become a good engineer.

If anyone had told the young graduate that his training had been deplorably narrow and that his college had failed to give such training as higher education should provide, he would have protested vigorously and emphatically. As far as extra-curricular activities went, had he not played a little football without coach or trainor, had he not performed frequently in a violin quartet, and had he not sung in a glee club that did not rehearse more than a few hours?

As far as education was concerned, were not American engineers the best in the world although nearly all of them had been trained in similar courses if college graduates?

He did not miss the well trained glee clubs, orchestras, and bands; the physical education and varied athletics; the honorary, literary, and technical societies; the military science and tactics training in discipline and coöperation; the debating, public speaking classes, and work on college papers and magazines; or the social training provided by fraternities, and the host of similar opportunities now available to nearly all college students. Especially, he did not miss the study of the humanities. Why should he miss these things? He knew little or nothing about them. People engaged in studying such things in college were sissies while he was a "he man." His college song glorified the fact that he drank his whisky clear and was, consequently, a rambling wreck.

LESSONS LEARNED FROM EXPERIENCE

Soon after graduation he began to write and somewhat later to engage in public speaking and he was then mortified to have his articles so drastically edited before publication that he hardly recognized them. He married a girl who had studied English for four years in college, and it was not conducive to marital harmony to be told by her that he wrote atrociously and that his lack of knowledge of sentence structure, grammar, and punctuation should have shamed a high school graduate.

Gradually, however, after doing some intensive studying and thinking about these matters, it began to dawn upon him that, ridiculous and improbable as the idea was, it was he who was out of step and not his wife or the editors.

Then began a period of several years of study of his own language than which there can be no study of more importance to any ambitious person—a study that certainly should have been completed in college.

Soon after he began to teach in his Alma Mater, a third of a century ago, he was disturbed to find himself and most of the other graduates of his institution badly handicapped when in the society of well educated men and women. He and they knew little or nothing about a large number of subjects that seemed very interesting and highly important and insignificant to many persons. He was further disturbed when told that a number of his students who were technically proficient had failed to secure or retain jobs because they were tongue-tied or made inexcusable grammatical blunders when introduced into groups of persons whose training had been different from their own.

He began to read omnivorously in an attempt to correct the deficiencies of his formal education—an attempt that has not been entirely successful and a procedure that many technical graduates lack the inclination and time to follow.

Your speaker believes that, if the picture he has painted is dark and dismal, no brighter colors could honestly have been used. His course was fairly typical of those which contemporary engineering students took. Older men may have benefited from the persistence of the ideals back of the classical curriculum that was the only higher education available to most of our forefathers, and younger men have probably enjoyed advantages not available to the writer; but most engineering curricula are still open to the indictment that they are altogether too technical and deplorably narrow and they give the students far too little time for desirable extra-curricular activities.

It has been said, and the observations of your speaker force him to concur, that most European engineers are first of all educated, cultured gentlemen, and, second, good engineers, while, with notable exceptions, American engineers are too frequently very able technicians and little less. It is a well known fact that professional engineers who are trained in Europe spend more than four years in college. If this indictment (that engineers are narrowly trained) be true, the engineering colleges are alone to blame.

You may have had a course in contemporary civilization or something of that kind, one in English, and one in economics, but, unless you have done a lot of reading and studying and thinking since you left college, your interests are narrow and the horizons that limit your visions are still terribly restricted, as were your speaker's when he graduated.

Futile Attempts to Improve the Four-Year Curricula

When your speaker joined the staff of the University of Arizona as Dean of the College of Mines and Engineering, twenty-one years ago, he found that the engineering students were required to earn 144 semester units (since increased to 145 by the addition of physical education in the Freshman year) before they could graduate, an average of 18 units a semester, while the other students on the campus were compelled to secure only 124 units, an average of 15.5 units a semester. Moreover, it certainly took an average engineering student more time to earn a semester unit than it did an average student in other colleges since it was easy to make assignments in mathematics and other sciences that it would require the average student at least two hours to cover, and failure to attain a certain degree of mastery of several successive assignments was almost certain to lead to such nebulous understanding of later assignments that failure in the course was certain. Moreover, in shop, drafting room, laboratory, and field courses, which made up a large proportion of the engineering curricula, a student had to be actually present three hours a week in order to gain a unit. These conditions still prevail and explain why an 18-unit schedule is so much heavier than one of 15.5 units. Theoretically, there should be a difference of only about 7½ hours a week, but actually the difference is nearer ten or twelve clock hours or about two hours a day. Nineteen or more units a semester are, furthermore, occasionally required and then the difference is more pronounced. Even one more hour of leisure a day would mean a lot to engineering students.

In spite of the heavy load that his students were expected to carry, your speaker found that the University of Arizona engineer-

ing curricula were an improvement over that of his Alma Mater in that one year of English and one year of some foreign language were required. Later, a year of economics was substituted for the foreign language and some electives were introduced into the senior year. Your speaker is often inclined to reproach himself because he has been unable to do more, but what could he do?

It is easy enough to say that the fundamental sciences used in engineering should be emphasized and considerable work in the humanities required as is done in the four-year curricula given at Yale, but the graduates of your speaker's college could not get jobs if that were done, and this statement applies to the graduates of most engineering colleges. Certain skills are demanded of them, and that means that applications as well as principles must be taught. Graduates in mining engineering, for instance, must be good assayers and chemists, competent surveyors, and fairly good draftsmen; they must be able to test ores and to determine the best methods to be used in treating them; they must know how to handle mining and metallurgical machinery and equipment, etc., etc. They may be called upon to do any and all of these things and many others in addition to the geological and engineering work involved in the exploitation of our mineral wealth. To give them this knowledge and skill, to introduce an appreciable amount of the humanities into their courses, and to give them time for meritorious extra-curricular activities in four years is an utter impossibility. Perhaps this fact explains why the football team of your speaker's Alma Mater has not won an important football game in decades. It is still considered to be something of a disgrace there if a student does not finish his course in four years.

The Existing Situation

The following statements are undeniably true of engineering students in your speaker's college:

1. Failure in a single course, even if due to causes beyond a student's control, such as illness, will force him to spend 4½ to 5 years to gain a Bachelor's degree unless he makes up his work in some summer session, and that can rarely be done if he fails in a heavy course that runs through an entire year.

Students in non-engineering curricula can fail in several courses and still graduate in four years.

2. Only students of exceptional ability who learn very quickly can engage in any outside work to help pay expenses and still graduate in four years.

Students in non-engineering curricula can earn a considerable part of their expenses while studying without lengthening their courses.

3. Only students of exceptional ability who learn very quickly, can engage to any considerable extent in "bull sessions," social diversions, and extra-curricular activities and still graduate in four years. They cannot possibly complete a course in that time if they wish to engage in such time-consuming things as playing football, editing a college paper or magazine, engaging in debate or dramatics, etc.

Students in non-engineering curricula can do all of these things without lengthening their courses.

4. The amount of attention that an engineering student can give to non-technical and non-scientific courses and graduate in four years is almost neglible.

In no other college curricula is there so little time for such things.

The situation that has been outlined as existing in your speaker's institution is, he believes, typical of that which exists in most engineering colleges, but it is especially serious in those colleges that are parts of universities. There the majority of the students have ample time to take advantage of the varied opportunities that college should offer everyone, and our engineering students cannot understand why we should differentiate against them, and why should we? The facts that their average ability is unusually high and that they are serious of purpose should make us terribly ashamed to handicap them.

Perhaps it may be claimed that engineering is such a difficult profession and demands so much of those who follow it successfully that we are justified in over-burdening our students in the expectation that we shall thereby weed out those who lack the ability to concentrate on their tasks and to work long and faithfully on any job assigned to them. This argument is sometimes voiced, but it makes no impression on your speaker. Physicians have as hard and as responsible jobs as engineers, but they are not overburdened while in college in an attempt to weed out the unfit. The time spent on their college training has been lengthened just as your speaker believes engineering curricula should be.

What Has Been Done?

Your speaker is only one of many who have changed their minds about the desirability of lengthening engineering curricula. When he reported on the development of mining engineering education between 1910 and 1925, which report appears in Vol. XXXII of Engineering Education, twenty-five per cent of the mining engineering Deans or Presidents favored lengthening the curriculum.

At the meeting of engineering Presidents and Deans that was held in Madison in July, 1933, the belief that engineering curricula should be lengthened was expressed by so many that a committee was appointed to investigate the matter and report to S. P. E. E. Your speaker was a member of that Committee, and, when a report was submitted for his approval last spring, he was surprised to find that it covered several subjects, but not the particular one at issue. He, therefore, submitted a minority report which was published with the majority report in the October, 1935, issue of our JOURNAL. The quantity of correspondence that has resulted would indicate that there is a very general feeling among engineering instructors that our curricula should be lengthened. You are doubtless aware of the fact that among the institutions that are now offering some form of lengthened curricula are Harvard, Princeton, Dartmouth, Columbia, Northwestern, and Stanford.

We are supposed to have four-year engineering curricula at the University of Arizona, but only fifteen per cent of the engineering freshmen registered there this year took the full freshman course and may receive their degrees in four years. Some of *them* will be forced to lengthen their curricula because of failure or for other reasons. During the addresses that your speaker delivers to his first-year students in Freshman Week, he strongly urges *all* of them to plan from the beginning to take five year courses and the figure just given proves that his advice is largely followed.

Because of conflicts and for other reasons, the courses the students of such lengthened curricula now pursue are not nearly as satisfactory as they would be if five-year curricula for all engineering students were arranged.

Dean A. A. Potter of Purdue and other engineering administrators who met in Washington last winter admitted that many of their good students who fail in nothing took five years to obtain Bachelor's degrees for one reason and another. Many of us are, then, already operating under a five-year plan, and probably the majority of the engineering students in the United States are taking more than four years to complete their courses, but we refuse to recognize the situation and to institute changes that will benefit our students.

At the breakfast held in Washington last November, attended by S. P. E. E. members, over which President Anderson presided, it was decided that this convention would be largely devoted to the problems that arise because of the fact that it is our duty to do much besides attempt to make our students good technicians, and it was freely admitted that it might be necessary seriously to con-

sider lengthening our curricula as the only way to broaden and liberalize the training that our students receive. The subject is certainly a very live one, and those of us who believe that most engineering curricula must eventually be lengthened have been much encouraged by the developments of the last few years.

If you ask why your speaker and others who agree with him on this matter do not lengthen the curricula administered by them, regardless of what others do, the answer will be that most preparatory school graduates have not been educated to believe that more than four years should be spent in preparing themselves for engineering work, and any institution that lengthens its engineering curricula will suffer a heavy loss of students. Unless most good engineering colleges decide to lengthen their courses at about the same time, many of them cannot afford to make the change. As it happens, however, enrollment in engineering at Arizona is growing too rapidly to suit us there, and we may soon follow the lead of the other institutions mentioned and adopt lengthened curricula regardless of what others do in the hope that we may thereby keep our enrollment at a figure that satisfies us.

Comments on Objections

Your speaker is well aware of the fact that "The Report on the Investigation of Engineering Education," issued by our Society in 1930, contained the recommendation that "the normal length of the undergraduate curriculum should remain four academic years," but he disagrees with that and some other recommendations made in that report. He has also read several papers written by educators who oppose the change he advocates. From all available sources, he has collected a list of reasons for objecting to lengthened engineering curricula, which he will now give and comment briefly on each.

1. The present type of engineering curricula has been generally taught in American engineering schools for 85 years with satisfactory results. Why change?

Comment.—There can never be progress if we blindly assume that what has been and still is the general practice is certainly superior to any new way of doing things that may be suggested. Merely because the results have been good is surely no proof that better results cannot be secured. Your speaker has tried to present facts that show that the results have not really been satisfactory.

2. Some engineering colleges have tried and then abandoned lengthened curricula.

Comment.—As already stated, the adoption of this plan by a single institution is almost sure to decrease the enrollment. Only simultaneous adoption of the plan by many institutions will prevent this effect.

3. Many engineering college graduates enter what may be regarded as a period of apprenticeship during which their employers really give them a graduate course in practical matters closely connected with the business, and, sometimes, in academic subjects. Such courses make lengthened curricula unnecessary.

Comment.—Those students who enter such courses are in the minority. The humanities are not taught in them and little training for citizenship is given. Such training courses do not provide the education that your speaker advocates.

4. If we had lengthened curricula our graduates would be too old.

Comment.—This objection strikes your speaker as one of the weakest offered. If one more year in college will possibly give our students training that will tend to make their lives fuller, richer, happier, and more useful for several score years, how can that period of time be better spent? All doctors of medicine and many college-trained lawyers remain in college even longer than the period your speaker advocates. If they are not too old when they graduate, why should that be true of engineers?

5. The added expense of lengthened curricula will prevent many promising young men from taking engineering or completing their courses.

Comment.—If an engineering student must earn even part of his expenses, he must usually now take a lengthened curriculum, although students of other colleges, now registered in the University of Arizona, are being paid for working eight to eleven hours a week and are still carrying courses heavy enough to enable them to graduate in four years. Plenty of students are studying law and medicine in spite of the greatly lengthened curricula in those subjects. It is entirely probable that we should still have plenty of engineering students even though our curricula were extended to as much as six or seven years. It is also very likely that the type of students who should go to trade schools, which handicap and embarrass engineering instructors now, would be discouraged when confronted with lengthened, liberalized engineering curricula and that is a result that most of us would welcome. If curricula were lengthened, able, needy students could often be given fellowships or assistantships during their last year.

6. Engineering students generally find the study of the humanities distasteful and will benefit little, if at all, if "exposed" to a few more of such courses.

Comment.—Whether any course is fascinating and helpful or the reverse depends almost entirely upon the instructor. Your speaker has watched an audience of sixty practicing engineers listen spell-bound for an hour to an address on "Modern Tendencies in Poetry." In several American engineering colleges considerable proportions of the students now elect advanced work in English. In those engineering colleges that have already lengthened their curricula, few or no objections to the humanities courses included have been voiced. Many engineering students now find the study of descriptive geometry or calculus or strength of materials decidedly distasteful, but we require all of them to obtain a working knowledge of these subjects and do not question the wisdom of so doing. Practically all of us include English and economics in our curricula now. If we really believed that our students do not benefit from the study of these subjects, which many of them, unfortunately, dislike, they would be dropped.

7. If our curricula are lengthened, the technical departments will demand more time with the result that, while the students will have time to engage in extra-curricular activities, no humanities can be added and the curricula will not be liberalized.

Comment.—An administrative problem like this should not worry us. Any engineering Dean or President who cannot prevent the addition of more technical courses ought to lose his job. If such action is taken in a few schools, that will be unfortunate, but a part of the criticism directed at our terribly over-crowded curricula will have been met.

8. The employers of engineering graduates are not demanding that curricula be lengthened and liberalized and are not convinced that the graduates from such curricula will serve their employers more satisfactorily than the graduates from four-year curricula. Many employers believe that a year spent in their organizations will make engineering graduates more valuable to the employers than would an additional year spent in college.

Comment.—How can employers possibly ascertain whether engineering employees would or would not have been more valuable to them if they had graduated from lengthened and liberalized curricula. They cannot know what latent abilities might have been developed, what self-confidence might have been engendered, what modifications of character might have taken place if their employees had graduated from such curricula. They do know something about the effects of graduate training, but we are considering only undergraduate curricula which will give students no more technical training than our usual so-called four-year curricula give.

As a matter of fact, we have no reason to be concerned about the attitude of employers toward the proposal to lengthen and liberalize our curricula. It is exceedingly doubtful whether a single employer would dare claim that graduates from such curricula would be unacceptable to them and would probably prove less satisfactory than men trained in four-year courses. That being true, our interest in the matter should depend upon the probable effects of such broadened and lengthened curricula upon the lives of our students. If such curricula are fairer in comparison with non-engineering curricula, if they will tend to remove the handicaps under which many engineering graduates work, if there is a good chance that they will broaden the interests of many of our graduates, enrich their lives, and make them happier men and better citizens, we should not be satisfied until such curricula have been generally substituted for the four-year courses, regardless of what employers may think about the plan.

Your speaker can recall no other objections, and must confess that those presented do not strike him as at all serious or justify us in failing to lay a real and broad foundation upon which our graduates can easily and satisfactorily build the rest of their lives.

Recommendations

Your speaker believes and recommends that 16 standard semester units should be required during the first four years of each engineering curriculum or a total of 128 units, and that only a slight degree of specialization in the various engineering fields should be permitted. The Bachelor of Science degree without any engineering designation should be granted at the end of this course, and the students should be told frankly and plainly that they will not be considered to have completed the minimum college training required of an engineer and will not be helped to obtain engineering jobs when they secure that degree. At the end of a fifth year, an appropriate degree such as Graduate Civil Engineer, should be granted, and the work of this year should be largely in that branch of engineering that is mentioned in the degree conferred.

At least 160 units can thus easily be earned in five years without the great over-crowding of programs that now prevails. No additional technical subjects should be added. The fifteen or more additional units earned should all be in the humanities—subjects that are intended to make better citizens and more broadly educated men of the engineering graduates.

Many persons who heartily favor lengthening and broadening our university engineering curricula are strongly opposed to the

idea of entrusting our students for two or more years to a Liberal Arts College. They believe that the best results will be secured if both technical subjects and the humanities are taught throughout an entire five-year course. Indeed, there is reason to believe that engineering students will not profit as much from studying the humanities as freshmen or sophomores as they will if they take such subjects later. Engineering faculties should probably control undergraduate engineering curricula from the first.

Your speaker does not intend to criticize in any way the institutions that have already lengthened their engineering curricula to more than five years. There is doubtless a need for some such institutions. He would be entirely satisfied if most first-class engineering colleges discontinued the ostensible attempt to train men for engineering careers in four years with the consequent overcrowding of courses and the denial to engineering students of the privileges and training that should be theirs.

It is not, of course, essential that the particular program outlined be followed or that the specific degrees mentioned be used, but the suggestions seem reasonable and your speaker believes that such a program would go a long way toward broadening the training given and the opportunities open to the engineering students, and he keenly regrets that he was not permitted to pursue such a course.

SOME NOTES ON THE GRADUATE SCHOOL OF THE CHRYSLER INSTITUTE OF ENGINEERING

By ALEXANDER KLEMIN

Daniel Guggenheim School of Aeronautics, New York University

The organization and functioning of the Chrysler Institute of Engineering seem to have many points of interest for the teacher in a College of Engineering or in a technical school.

The Institute had its inception in the conviction of three well known automotive engineers, Fred Zeder, Carl Breer and Owen D. Skelton, that transition from an engineering school to industry was a very difficult stage in a young man's career, in particular as regards obtaining professional work suited to his abilities. In busy times industry would indeed send scouts to the campus to secure the most capable men with promises of interesting work and rapid promotion. But once these young men were safely within the walls of the factory, the situation was apt to change. A fine young engineer might be put to work making one routine test for month after month. A brilliant mathematician might be placed at a drawing board on work for which he was fundamentally unfitted. An ingenious designer might be assigned to the monotonous task of keeping engineering records and blueprints. It was realization of the carelessness with which industry misused capability and youthfulness which led these three men to suggest to Walter P. Chrysler the establishment of the Institute.

The specific incident which brought matters to a head was the evaluation of a series of examination papers answered by Chrysler engineers, all of them technical graduates with recognized degrees. The examinations included such topics as English, Applied Mechanics, Physics, etc. . . . It was found that engineers made no more than 50 per cent grades in these fundamental subjects, and that their written English was woefully weak. The examinations also disclosed a lack of cultural background amongst the engineers. The designers of automobile bodies knew nothing of art or its history and similar gaps were discovered in other departments.

At about the same time it was realized by engineering executives that there was no direct line of contact between the engineering college and the factory. The experiences of college graduates when first entering industry were rather sad. If they entered the shops they were apt to find themselves handicapped by a lack of

mechanical skill and by the hostility and suspicion of the workmen. If they entered directly into the engineering or drafting departments they were handicapped by ignorance of fundamental shop processes. If, on the other hand, they took up administrative work after leaving college, they lacked knowledge of the working man's psychology and of industrial life in general.

These considerations provided the guiding principles for the organization of the Institute's graduate school.

Scholastic Methods

The Institute was incorporated in June 1933 under a Charter of the State of Michigan, and can confer any degree up to that of Doctor of Engineering. In its two year graduate course, the degree granted is that of Master of Mechanical Engineering.

In February and June of every year, young men who have recently graduated from accredited colleges of engineering are carefully selected for admission. Written applications are sifted down by Professor John J. Caton, the Director of the Institute, and the more promising candidates are interviewed by an educational committee of eight executive engineers. Competition for entry is exceedingly keen. Although the number of students admitted annually is only 20, the number of applicants during 1935 was approximately 3000 and included many men with a Master's Degree, and a few had already attained to a doctorate. These 3000 applicants were reduced to one hundred men, who were painstakingly and carefully interviewed for the final selection of the fortunate twenty. It is only natural that competition should be keen, since admission means a combination of graduate instruction with a systematic form of technical apprenticeship, plus remunerative which is ample for maintenance of comfortable living standards.

Part of the curriculum consists of actual practice five days a week from early morning till 3 P.M. in the research and engineering laboratories and offices of the Chrysler Company. Students are rotated on a definite schedule, spending from one to four months in such departments as engine research and testing; applied thermodynamics; materials investigation; automobile dynamics; automobile aerodynamics; lubrication; testing to destruction; metallurgical laboratory; chassis design; mechanical design; etc., etc. . . . No matter how proficient a graduate student may show himself to be in any one department, and no matter how insistent the Department Head may be in wishing to retain the man, the rigid rule of rotation is observed. There is no doubt, of course, that graduate studies should involve research, but the

students are employed almost exclusively in the research and experimentation which is the very essence of modern automotive engineering. The bulletin of the Institute states that the young men are given an opportunity of "doing," "seeing," "weighing" and "analyzing" the engineering of an automobile.

The practical application of engineering fundamentals is paralleled by a scholastic program which also operates five days a week, beginning at 3 P.M. All the men are required to follow an identical curriculum as follows:

GRADUATE ENGINEERING

First Semester	*Hours*	*Second Semester*	*Hours*
Applied Physics to Engineering Problems	2	Applied Physics to Engineering Problems	2
Public Speaking	2	Public Speaking	2
Commercial Law	1	Commercial Law	1
Automotive Engineering	1	Automotive Engineering	1
Psychology	2	Psychology	2
Applied Advanced Engineering Mathematics	2	Applied Advanced Engineering Mathematics	2
Third Semester		*Fourth Semester*	
Commercial Law	2	Automotive Engineering Design	2
Automotive Engineering Design	2	Public Speaking	2
Public Speaking	2	Psychology	2
Psychology	2		

The methods of instruction do not differ substantially from those of an engineering college, with exercises, term examinations, grades in the approved University style. However, the Professors of Physics, Mathematics, Automotive Engineering, and Automotive Design are practicing engineers employed in important positions in research or experimentation. Standards of discipline and attainment are high.

SOME NOTEWORTHY FEATURES

The following are outstanding impressions gained from a lengthy visit to the Institute, and detailed discussions with Professors and Department Heads (in some cases men act in dual capacity).

Detroit, in its manufacturing centers, is the very embodiment of practicality and hard headedness. Yet, the curriculum of instruction lays more emphasis on the application of physics and mathematics than on strictly professional subjects.

The young men work hard. Between their research and experimentation in the early part of the day, their school work later

in the day and in the evening, their subsequent reviews and studies at home, their lives are well crowded. Nevertheless, time is found for psychology, public speaking and commercial law. The intensely practical automotive engineers agree with modern engineering college conceptions regarding the desirability of including cultural subjects in the curriculum.

Relatively few text-books are used, as the directing heads of the Institute feel that text-books are seldom sufficiently up-to-date. The view is held that engineering society papers and articles in the technical press never disclose practice completely and are apt to be descriptions of developments completed years ago. Inasmuch as most technical text-books embody the findings of these special papers and articles, there is always present the danger that college instruction in professional subjects is out-of-date and only partially well informed. As a consequence, the reference material of students at the Chrysler Institute of Engineering is mainly in the form of mimeographed notes which are always undergoing revision.

The classical system of examinations and grades, criticized so frequently by students and engineers who have once been students, appears nevertheless as almost inevitable in the process of education.

The Institute has the right to grant a bachelor's degree, but while hundreds of employees of the plant receive evening instruction in college and professional subjects, the bachelor's degree is very rarely granted and the consensus of opinion was that undergraduate instruction in engineering was a matter best left to the universities.

Graduate students of the Institute appear to occupy in the industry a position analogous to that of a midshipman on a battleship. They are close enough to the workmen (who may, at times receive instruction in the same classroom and from the same man), to arrive at an understanding of their psychology and to meet them on thoroughly friendly terms—a very important experience in an engineer's career. They frequently work together with skilled artisans on very similar tasks but they do not arouse the animosity which mere routine work in the shop and the apparent displacement of a workman often arouse. Another reason why friendliness between the future engineering executives and the shop is enhanced is because every student is given an opportunity to instruct shop foremen.

These men in their experimental or research work are expected to be as efficient and as hardworking as any young engineer in the place, but there is a subtle difference in the attitude of their superiors, who demand good work but understand that they must

instruct. Moreover, inefficiency in a single particular department is not a cause for dismissal. There may be a somewhat earlier transfer than usual with the expectation that the beginner will probably do far better in some other department. As a rule, in general industry, the recent graduate is put at some minor task. If he is considered unsatisfactory, he is apt to be summarily discharged, even though the duties assigned to him were entirely unsuitable to his special abilities or temperament.

At the University the graduate engineering student is apt, at times, to be impatient with his research work and to consider his thesis somewhat lightly. This may be, perhaps, because the problem allotted to him by the professor in charge is of an academic character. At the Institute the research work is strictly 'ad hoc' and seldom fails to engage the budding technician's full interest. There are some extraordinary examples of achievement on the part of these graduate students while still working towards their master's degree. Thus, at one time, considerable difficulties were being experienced in the matter of braking fluids. One of the newly fledged engineers was called into a corner to see what he could do towards the improvement of such fluids. After only three months work he found that he had lowered the freezing point of the brake fluid 14 degrees and raised the boiling point 15 degrees higher. At the same time, the newly developed fluid could be manufactured at 60 cents a gallon less than any fluid purchased on the outside with a saving of $180,000 a year in brake research work. This instance of graduate student achievement is but one of many.

Another practice which appears to be of value is that of allowing students to attend sessions of administrative committees of the engineering laboratories—without participation in discussions of course. Such an experience is the first step in the development of administrative or executive ability.

That engineers take a great deal of time to find themselves has been brought out by a recent study by the American Society of Mechanical Engineers made with men some twenty-five years out of engineering school. A careful study of the replies brought out the sad fact that after this long lapse of time 80 per cent of the men had either abandoned the practice of engineering, or were still "square pegs in round holes." This difficulty of engineers finding their true vocations has been carefully developed by this factory within the university. The students passing through various departments invariably show their true bent, and at the end of their course, almost invariably find their true place in automotive engineering with the Chrysler Company or elsewhere.

Approved by Academic Authorities

Apparently this effort in practical engineering education has been widely approved by academic authorities all over the country as demonstrated by the granting of reciprocal credits, etc. . . . Prof. H. C. Anderson, of the University of Michigan, considers the undertaking to be an ideal bridge between the University and Industry and far more than a method of attracting and training the best young engineers for one particular company. Prof. Anderson thinks that this is a remarkable work, both of guiding and developing ability throughout the entire field of industry, and one which might revolutionize many concepts of technical education in the United States.

Some Conclusions

There is all the more likelihood of agreeing with Prof. Anderson, when one considers the equal success of similar efforts by Westinghouse, General Electric and Bell Telephone. It is not conceivable, nor is it desirable that such plans should become universal, and that the University graduate school of engineering should be superseded. It is important, however, for College administrators and teachers to study these departures and to draw therefrom all the guidance possible. The following conclusions are tentatively presented:

1. Even in a graduate course of a professional character, instruction should not be solely of a specialized nature. More advanced work in the fundamental sciences of mathematics, physics, etc., should be an integral part of an advanced course.

2. In graduate studies, emphasis should be shifted from textbooks to the latest technical publications, and professors should be able to supplement all sources of reference by virtue of close contact with industry.

3. With students in engineering, research undertaken should have, for the most part, a strongly industrial bent.

4. Students, on leaving the University, should be encouraged to seek, not positions offering the maximum in immediate return, but openings in which some degree of rotational service in various departments is in prospect.

5. Finally, college teachers should bring all possible pressure to bear on their engineering colleagues in industry to think with some degree of consideration of the new human material placed at their disposal and to plan for bridging the gap between the schools they have themselves frequented and the factory.

PROGRESS REPORT OF THE COMMITTEE ON TWO-YEAR TERMINAL PROGRAM

On February 20, 1936, the President of the Society for the Promotion of Engineering Education appointed a Committee on Two-Year Terminal Program composed as follows:

B. F. Bailey, University of Michigan
J. W. Barker, Columbia University
R. E. Doherty, Carnegie Institute of Technology
E. A. Hitchcock, Ohio State University
C. M. Jansky, University of Wisconsin
P. R. Kolbe, Drexel Institute
Louis O'Shaughnessy, Virginia Poly. Inst.
B. R. Van Leer, University of Florida, *Chairman.*

The Chairman immediately communicated with all members of the committee and asked for their suggestions as to the work and procedure by which the committee could operate and carry on its work by correspondence, as there was no opportunity or funds for a general committee meeting.

It developed that there was considerable difference and divergence of opinion among the members of the committee as to just what the field of activity of the committee should be. In order to determine in a democratic manner how the committee felt on the various questions and subjects which members of the committee had proposed, a questionnaire was prepared and sent to the committee. The questionnaire, with the votes of the members of the committee, is shown below.

QUESTIONNAIRE

Proposals and Opinions from Members of S. P. E. E. Committee on Two-Year Terminal Program for Engineering Students

1. The committee recognized this field of work to embrace the following:

a—1. First two years work for students of a large university who think they would like to be engineers, yet subsequently find that because temperament or mental capacity they are unsuited to continue the work for an engineering degree.

Yes 5 No 2

a—2. The problem here is to provide a program sufficiently broad that the student will not have wasted his two years heading toward an engineering degree, yet sufficiently specialized that he will be fitted to undertake work in an upper division of an engineering college.

Yes 6 No 2

b—1. First two years work in Junior colleges for students who will subsequently study engineering in another institution.

Yes 4 No 3

b—2. The problem here is similar to *a*—2 above, but is further complicated by the fact that it is difficult for many Junior Colleges to secure either adequate equipment or instruction staff to properly prepare a student to enter the upper division of an engineering college.

Yes 4 No 2

c—1. First two years work in technical institutes or schools of technology.

Yes 4 No 3

c—2. The problem here is again similar to *a*—2 and *b*—2, but is further complicated by the fact that probably a larger proportion of these students would and could make excellent workmen in the sub-professional work of an engineering nature such as drafting, surveying, etc.

Yes 4 No 2

d—1. First two years of technical institutes and trade schools.

Yes 5 No 2

d—2. The problem here is to have a two-year program which will produce competent workmen and craftsmen in that length of time and still give a sufficiently broad and thorough training in the sciences—mathematics, etc.—so as not to unduly delay the minority group which desires and is competent to go on for additional work leading to a degree in engineering.

Yes 4 No 1

2. The committee believes there is a common minimum program of work applicable to all of these groups.

Yes 3 No 3

3. The committee will attempt to ascertain what that common minimum is.

Yes 4 No 2

4. The committee authorizes the chairman to attempt to secure for the S. P. E. E. papers by competent interested people on these phases of its work.

   Yes 4 No 1

   (If you vote yes on this the chairman will expect you to suggest at least one competent person who will prepare a paper on at least one of these questions.)

5. The chairman is authorized to approach the Office of Education and endeavor to secure its aid in assembling data on these questions.

   Yes 7 No 0

6. Do you favor sending to all institutional members of S. P. E. E. an appropriate questionnaire on what the contents of the first two years engineering curricula and terminal facilities should be?

   Yes 5 No 1

7. Do you favor establishment of standards for a Junior certificate or an Associate of Arts which an engineering student may secure at the end of two years?

   Yes 4 No 2

8. Do you believe such a device could be made a minimum standard for admission to the upper division of Colleges of Engineering?

   Yes 4 No 2

The committee agreed that where there was practically an equal division of opinion it would omit consideration of that topic for the time being and pass to those concerning which we were all in practical agreement. Thus Item 1: that the committee's work would embrace the first two years for students of large universities who think they would like to be engineers, yet subsequently find that because of temperament or mental capacity they are unsuited to continue work for an engineering degree. It is the intention of the committee to investigate this field.

The committee also is committed to an investigation of the terminal program for the first two years at technical institutes and trade schools.

The committee authorized its chairman to attempt to secure for S. P. E. E. papers by competent and interested people on these phases of its work. Up to the present time, the chairman has been unsuccessful in securing any volunteers and must, therefore, press someone into service. He is open to suggestions.

The committee also plans to approach the Office of Education in an endeavor to secure its aid in assembling data on these questions; and to approach the institutional members of the S. P. E. E. with an appropriate questionnaire on the content of the first two years of engineering curricula and terminal facilities.

You will be interested to note the stand of the committee on items 7 and 8 of the original questionnaire. The committee favors the establishment of standards for a junior certificate or Associate of Arts which an Engineering student may secure at the end of two years; and the committee was inclined favorably toward such a device as a minimum standard for admission to the upper division of colleges of engineering.

Due to the late date at which this committee was formed, the necessity of conducting all of its work by correspondence, and the fact that the committee was not at all times of one opinion on all of these questions, a policy was not arrived at in sufficient time to carry out the above recommendations prior to June 1936 annual meeting of the S. P. E. E.

The committee therefore recommends that this committee, or a similar one, be continued and requested to pursue the work outlined in this report for the coming year and be requested to make a report upon the several items in question at the next annual meeting of the S. P. E. E.

Respectfully submitted,

B. R. VAN LEER, *Chairman*

REPORT OF CONFERENCE ON COMPREHENSIVE EXAMINATIONS

A conference on comprehensive examinations and tests was held on Tuesday afternoon, June 23, with C. V. Mann, Missouri School of Mines, presiding for W. H. Timbie, chairman. Eighty persons attended.

C. V. Mann read from the committee report the parts relating to the origin, work, past history, and projected program of the committee in charge of the conference. H. H. Armsby, Missouri School of Mines, presented his paper, "A Ten Year Study of Iowa Placement Examinations," illustrating the paper by lantern slides. The following is a summary of the discussion:

E. R. Wilcox, University of Washington, stated that the selection of engineering students at his university on the basis of Iowa Placement Tests and high school records checks completely with Professor Armsby's conclusions.

F. C. Dana, Iowa State College, stated that general psychological tests used at Ames in lieu of long testing programs accurately predicted achievement in engineering study in all but 11 out of 150 cases.

M. E. Nichols, Fenn College, stated that a one hour test shows abstract ability. Other tests are required for prediction of professional aptitude.

B. R. Van Leer, University of Florida, stated that the Iowa Math Aptitude Test alone, and the combined pattern obtained from administering all of the Iowa tests, do not differ very much for engineers.

A. V. Millar, University of Wisconsin, called attention to the inaccuracy of predictions made at the University of Wisconsin, using the American Council on Education Psychological Test. He presented a series of several lantern slides showing the errors that had been made in prediction on such a basis. (Note: This observation checked with conclusions presented in the paper by George Thom, Swarthmore, who stated in his paper that the American Council Psychological Test was unsuited for making predictions of engineering scholastic success, either for individual students, or for class groups as a whole. His paper dealt fundamentally with usage of the Lehigh sophomore comprehensive examinations, and showed that they were practically as effective as grades in predicting graduation as seniors.)

Paul Cloke, Maine, presented a paper, illustrated by charts, describing the construction and use of comprehensive examinations in engineering classes for both sophomores and seniors. Correlations between test scores and cumulative scholastic standing were high, as were correlations between scholastic achievement factors for sophomore and senior years. Samples of the Maine comprehensive examinations were shown.

Stewart Scrimshaw, Marquette, stated that comprehensive examinations should be made to include various elements outside of purely technical matters of engineering.

The conference chairman outlined briefly the work of E. C. P. D. in guidance and selection of engineering students and asked for an expression of opinion as to whether the S. P. E. E. committee should, in view of the proposed activity of E. C. P. D., continue in the field of work covered by the papers and discussion in the present conference.

Although this was called a Conference on Comprehensive Examinations most of the meeting was devoted to Placement Tests and Psychological Examinations and the following facts brought out: Placement tests are now widely used; these tests are excellent guides. Some of them, notably the Iowa tests, give results highly indicative as to the probability of success in college.

The discussion showed lack of complete confidence in intelligence tests (possibly placement tests also) because notably in the lower ranges they failed to predict individual cases as reliably as in the upper ranges.

It was recommended that the Committee continue its work and that it coöperate with the E. C. P. D. committee in this field. It was also recommended that the committee define and set up the objectives of comprehensive examinations; extend its activities to include the collection of experiences of others; and develop better questions.

JUSTUS RISING,
Secretary.

NECROLOGY

GENERAL ROBERT I. REES, a past President of this Society, died on November 23, 1936, at the age of sixty-five.

General Rees was a graduate of the Michigan College of Mines. He devoted a year to graduate work at Harvard and another year to advanced study at the New York Law School. He was awarded honorary doctoral degrees by Worcester Polytechnic Institute in 1930 and by the Michigan College of Mining and Technology in 1933. General Rees entered the army in 1897 and served through the Spanish-American War, the subsequent Philippine campaign and through the World War. He resigned from the service in 1924. He was appointed to the rank of Brigadier General in 1918. He was graduated from the Army School of the Line in 1913 with the designation "distinguished graduate." He was also a graduate of the Army Staff College, in 1914, and of the Army War College in 1923. At the outbreak of the World War he was appointed to the general staff of the army in the War Plans, Executive, and Operational Division at Washington. In June 1918 he became Chairman of the Committee on Education and Special Training for the American Expeditionary Force and was in charge of all educational work of the Army in France where 287,000 enlisted men and commissioned officers attended regular schools and universities, and 1,600,000 members of the Army were reached by lecture courses and institutes organized by General Rees. He was awarded the Distinguished Service Medal in 1919 for "exceptionally meritorious and conspicuous servcie." He was an officer of the Legion of Honor. He was a member of the American Society of Mechanical Engineers, the American Association for the Advancement of Science, the American Association for Adult Education, American Institute of Mining and Metallurgical Engineers, Personnel Research Federation, American Management Association, the Army and Navy Club of Washington, the Machinery Club, and the Western Universities Club of New York City, and of Tau Beta Pi. From the time of his resignation from the Army in 1924 to his death General Rees was Assistant Vice-President of the American Telephone and Telegraph Company in charge of the employment and training of college graduates for the Bell System and for the general educational activities of that System.

General Rees' position in the field of engineering and of education was unique: not himself a teacher of engineering and having no affiliations with any college other than his membership on

Brooklyn Polytechnic Board of Trustees, he was universally regarded as one of the most valuable members of the general "family" of engineering education. He was the only man not a member of a college faculty who had been elected to the presidency of the Society for the Promotion of Engineering Education, and was the only member of the American Army to be decorated by the French Ministry of Education. At the same time he was one of the most active and influential members of the engineering profession at large. At the time of his death he was beginning a new service to that profession as Vice-Chairman and virtual director of the Engineers' Council for Professional Development, the joint agency of the major national associations of engineers and engineering teachers, having as its purpose the promotion of the professional interests of engineers. The activities in which General Rees engaged and the honors and distinctions that came to him were indications not only of the high order of his ability, but also and even more, of his character—of its strength and, at the same time, of its gentleness and simplicity. All who had the privilege of association with him recognized these qualities early in that association, and found their respect and affection for him growing steadily as time went on.

H. P. HAMMOND

ENGLISH NOTES

DEVOTED TO THE INTERESTS
OF TEACHERS OF ENGLISH
IN ENGINEERING SCHOOLS

J. L. VAUGHAN, EDITOR

SHORT BIBLIOGRAPHY OF REPORTS USEFUL IN TEACHING ELEMENTS OF REPORT WRITING

By A. C. HOWELL

Associate Professor of English, University of North Carolina

The following list of reports is by no means exhaustive; neither is it a mere random sample. In making up the list I have been limited by the library of the University of North Carolina and by by own collections, so that, though many fine reports may have been omitted, I have examined each report here listed and can assure the reader that the examples given do illustrate the types under which they appear. From the list I have eliminated certain well-known reports because they are rather old and consequently obsolete; among these should be mentioned the fine report of Alvord and Burdick on the Scioto Valley Flood Prevention, the Freeman report on the Hetch-Hetchy Water Supply for San Francisco, the Arthur Morgan reports on the Miami Conservancy District, the Chicago Transportation Report in three massive volumes, and a host of others. But enough of a variety in each classification has been listed to enable the English teacher to build up a representative collection of reports which illustrate all the features of good report writing. I shall be grateful for other items which for special reasons should be added to this list, and perhaps at some future time "English Notes" can publish a supplement.

It is my personal feeling that the student will be more thoroughly impressed if he can actually see and handle reports than he will by any number of apt illustrations in a text-book, and for this reason I would urge each English teacher to build up his own bibliography and collection of reports for use in class and as parallel reading. Some of the reports in this bibliography are as well written as any current literature and as interesting as fiction, and

the student should be urged to read and study them. Particularly should each teacher try to secure good local reports for class criticism and comment. A collection of forms used in routine reports is also valuable and almost any industrial or public utility plant will be glad to supply samples.

This bibliography is designed to be useful; therefore names of authors and addresses of publishers have been given where possible. Many of the government reports can be secured for modest sums; others will be furnished free to responsible people; and almost all of these reports are available upon payment of cost of the report. Since the purpose of this bibliography is to assist teachers conducting courses in report writing, I shall be glad to be of further service to any teacher who cares to write me for more detailed information.

Periodic Information Reports

Annual Reports from Representative Industries

(The group which follows is representative of the growing interest in attractive presentation of data in annual reports. Helpful for a study of these tendencies are two booklets issued by the Policyholders Service Bureau of the Metropolitan Life Insurance Company, One Madison Ave., New York City: *Charts and Exhibits in Annual Reports to Stockholders* and *Descriptive Information in Annual Reports to Stockholders.*)

Annual Report of the American Telephone and Telegraph Company, 195 Broadway, N. Y. C. (1930–35).

Reports of the Board of Directors to the Stockholders, The New York Central Railroad Company, New York Central Bldg., 230 Park Ave., N. Y. C. (1925–35).

Annual Report of the General Motors Corporation (1920–35).

Annual Report, The American Sugar Refining Company, 120 Wall St., N. Y. C. (1920–35).

Annual Report, The Baldwin Locomotive Works, Cons. (1925–35).

Annual Report, Consolidated Gas Company of New York, 4 Irving Place, N. Y. C. (1925–35).

Annual Report, The Pennsylvania Railroad Co., Office of the Secretary, Broad Street Station Bldg., Philadelphia, Penn. (1925–35).

(These reports are typical of the better sort of Public Annual Reports, well written, attractively illustrated and effectively presented. To this list should be added examples of the annual reports of municipalities, and state and national institutions, most of which are easily procured.)

Annual Report of the Westchester County Sanitary Sewer Commission, Court House Annex, White Plains, N. Y. (1929–36).

Annual Report of the Port of New York Authority, 111 Eighth Avenue, N. Y. C. (1920–36).

Annual Reports of the Westchester County Park Commission, White Plains, N. Y. (1928–36).

Special Information Reports

Preliminary Reports

The Port of New York Authority, *Tentative Report on Kill Van Kull Bridge* (Feb. 1, 1927).

Sacramento Flood Control Project, *Revised Plans*, Dept. of Public Works, Sacramento, Calif. (Feb. 10, 1925).

The Port of New York Authority, *Report on a Preliminary Investigation for a Proposed Bridge across Raritan Bay between Staten Island, N. Y., and Monmouth County, N. Y.* (1932).

Port Allen, Kauai, Hawaii, Letter from the Secretary of War, Transmitting a Letter from the Chief of Engineers, U. S. Army, Dated April 25, 1933, Submitting a Report, together with Accompanying Papers and Illustrations, on a Preliminary Examination and Survey of Port Allen, Kauai, Hawaii, Authorized by the River and Harbor Act Approved July 3, 1930; Department of War, Washington, D. C. (April 25, 1933).

Report of A Plan of Highway Improvement in the Regional Area of Cleveland, Ohio, Based on a Survey of Highway Traffic, by the Bureau of Public Roads, U. S. Department of Agriculture, and the County Commissioners of Cuyahoga County, Ohio (1928).

Progress Reports

The Port of New York Authority, *First Progress Report on Kill Van Kull Bridge between Bayonne, N. J., and Port Richmond, Staten Island, N. Y.* (April, 1930).

Ibid., Second Progress Report on the George Washington Bridge across the Hudson River at New York between Fort Washington and Fort Lee (March, 1929).

Ibid., Third Progress Report . . . etc. . . . (April, 1930).

Final Reports

The Bridge over the Delaware River Connecting Philadelphia, Penn., and Camden, N. J., Final Report of the Board of Engineers to the Delaware Bridge Joint Commission of the States of Pennsylvania and New Jersey (Philadelphia, 1927).

Construction of the Los Angeles Aqueduct, Final Report, Dept. of Public Service, City of Los Angeles (1916).

Examination Reports

State Planning, A Review of Activities and Progress (Washington, D. C., June, 1935).

Giant Power, the Report of the Giant Power Survey Board to the General Assembly, with a Message of Transmittal by Gifford Pinchot, Governor (Harrisburg, Penn., 1925).

Report of the San Francisco Bay Marine Piling Committee, *Marine Borers and Their Relation to Marine Construction on the Pacific Coast*, C. L. Hill, in Charge, Office of Forest Products, U. S. Forest Service (San Francisco, Calif., 1927).

Federal Power Commission, *National Power Survey, Interim Report*, Power Series No. 1 (Washington, 1935).

Ventilation, Report of the New York State Commission on Ventilation (New York, 1923).

St. Francis Dam Failure, by C. E. Grunsky and E. L. Grunsky, consulting engineers (San Francisco, March 12–13, 1928).

Report on Sewage Disposal, The Sanitary District of Chicago, Made to the Board of Trustees by George M. Wisner (Chicago, Oct. 12, 1911).

Frontinus and the Water Supply of Rome, by Sextus Julius Frontinus, Water Commissioner of the City of Rome, 97 A. D. (New York, 1913).

(This report is the oldest engineering examination report known. It has been beautifully translated, edited, and illustrated by Clemens Herschel. Every civil engineer should know it.

The following four reports are representative of thousands issued by the Engineer Corps of the United States Army. They are thorough, clear, and carefully organized.)

Skagit River, Wash. (Supt. Documents, Washington, D. C., Sept. 12, 1933).

Improvement and Development of the Neuse River, N. C. (Jan. 21, 1927).

Warrior and Tombigbee Rivers and Tributaries, Ala. and Miss. (Oct. 17, 1932).

Grand River, Missouri and Iowa (Jan. 27, 1932).

Economic Survey of the Book Industry, Final Report, by O. H. Cheney, Director, National Association of Book Publishers, N. Y. C. (1930–31).

Mining Methods in West Virginia, Research Bulletin No. 4, Engineering Experiment Station, West Virginia University, Morgantown, W. Va. (May, 1929).

(This report gives interesting accounts of the mining methods and machinery.)

Recommendation Reports

National Resources Board, *A Report on National Planning and Public Works in Relation to Natural Resources and Including Land Use and Water Resources with Findings and Recommendations*, National Resources Board, Interior Bldg., Washington, D. C. (Dec. 1, 1934).

(This is a truly monumental report, beautifully presented.)

Recommendations Including Brief Statement of Findings and Conclusions, The Engineering Board of Review of the Sanitary District of Chicago on the Lake Lowering Controversy and a Program of Remedial Measures (Dec. 20, 1924).

(This report was published as Part I of the examination report which follows. Both are effectively written.)

Report of the Engineering Board of Review of the Sanitary District of Chicago on the Lake Lowering Controversy and a Program of Remedial Measures. Part II: *The Technical Basis for the Recommendations of the Board of Review* (Chicago, Jan. 23, 1925).

(The following Report is monumental in detail, fact, presentation, appearance.)

Regional Plan of New York City and Its Environs, under the general direction of the Committee on Regional Plan, Frederick A. Delano, Chairman. (The volumes were prepared under the editorship of Thomas Adams, Director of Surveys.) (New York, 1931.)

Regional Survey of New York City and Its Environs (individual reports by staff members) 7 volumes (New York, 1927–33).

Report on the Preservation and Improvement of Niagara Falls and Rapids (Government Printing Office, Washington, D. C., 1931).

Marketing Reports

Zanesville and 36 Other American Communities, A Study of Markets and of the Telephone as a Market Index, *The Literary Digest*, New York (1927).

Report of a Research into the Attitudes and Habits of Radio Listeners, by Clifford Kirkpatrick, Ph.D., Webb Book Publishing Co., St. Paul, Minn. (1933).

The annual *Proceedings* of various engineering associations, such as the American Railway Engineering Association, the American Gas Association, and the American Society for Testing Materials, contain many interesting examples of short reports. Particularly useful are those embodying the use of questionnaires (*A. G. A. *Proceedings* (1932), p. 533 ff.; A. R. E. A. *Proceedings* (1929), pp. 306, 307) and reports of tests (*A. G. A. *Proceedings* (1931), p. 915 ff.; and A. R. E. A. *Proceedings* (1936), p. 747 ff.)

Research Reports

It is unnecessary to list here more than a few examples of research reports. They are turned out in thousands annually by engineering experiment stations and public and private research agencies all over the nation. If I may express a personal opinion, I should say that I have found effective the publications of the Iowa State College of Agriculture and Engineering, the University of Illinois Engineering Experiment Station, and the University of Michigan.

Spangler, M. G., *The Supporting Strength of Rigid Pipe Culverts*, Bulletin 112, Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa (Feb. 8, 1933).

Tykociner, J. T., Tarpley, R. E., and Paine, E. B., *Oscillations due to Corona Discharges on Wires Subjected to Alternating Potentials*, Bulletin No. 278, Engineering Experiment Station, University of Illinois, Urbana, Ill. (Sept. 17, 1935).

Emswiler, J. E., and Randall, W. C., *The Neutral Zone in Ventilation*, Department of Engineering Research, University of Michigan, Ann Arbor, Mich. (April, 1926).

* These are merely samples. Almost any volume will furnish helpful material for a study of report writing technique.

NEW MEMBERS

CALLAGHAN, JOSEPH C., Instructor in English, Lehigh University, Bethlehem, Pa. C. C. Williams, F. V. Larkin.

CRAWFORD, THOMAS S., Associate Professor of Chemical Engineering, Rhode Island State College, Kingston, R. I. F. W. Stubbs, R. L. Wales.

DENNISON, B. C., Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. Re-instatement.

DRAGER, FREDERICK E., Instructor in Civil Engineering, University of Idaho, Moscow, Ida. Ivan C. Crawford, A. J. Davidson.

ECKFELDT, HOWARD, Professor and Director, Curriculum in Mining Engineering, Lehigh University, Bethlehem, Pa. Hale Sutherland, S. A. Becker.

GAYLORD, EDWIN H., Associate Professor of Civil Engineering, The Ohio University, Athens, Ohio. F. L. Plummer, A. A. Atkinson.

GIBBS, FRED P., Instructor in Engineering Drawing and Machine Design, University of Colorado, Boulder, Colo. Wm. F. Brubaker, W. Otto Birk.

GRUBER, HOWARD D., Assistant Professor of Electrical Engineering, Lehigh University, Bethlehem, Pa. S. S. Seyfert, Hale Sutherland.

JENSEN, CYRIL D., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. Hale Sutherland, H. G. Payrow.

KEEVIL, CHARLES S., Professor of Chemical Engineering, Bucknell University, Lewisburg, Pa. R. C. Kintner, R. A. Gardner.

LITKENHOUS, EDWARD E., Assistant Professor of Chemical Engineering, University of Louisville, Louisville, Ky. R. C. Ernst, W. B. Wendt, B. M. Brigman.

MENUEZ, EDWARD A., Instructor in Civil Engineering, University of Toledo, Toledo, Ohio. D. M. Palmer, W. F. Brown.

MOSER, KENNETH J., Instructor in Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. James Creese, G. W. Barnwell.

O'DONNELL, WILLIAM J., Instructor in Civil Engineering, Manhattan College, New York City. Bro. A. Leo, J. C. G. Seidl.

OLIN, HUBERT L., Professor of Chemical Engineering, State University of Iowa, Iowa City, Iowa. A. H. Holt, H. O. Croft.

POTTER, JAMES L., Instructor in Electrical Engineering, State University of Iowa, Iowa City, Iowa. G. F. Corcoran, C. J. Posey.

PRIAR, VASILY D., Instructor in Mechanics and Mathematics, Fenn College, Cleveland, Ohio. D. C. Fabel, M. E. Nichols.

REMMERS, H. H., Professor of Education and Psychology; Director, Division, Educational Reference, Purdue University, Lafayette, Ind. C. V. Mann, J. B. Butler.

ROOP, FRANK S., Instructor in Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. Louis O'Shaughnessy, J. B. Jones.

SIMMERING, SIEBELT L., Professor and Head, Department of Mechanical Engineering, University of Colorado, Boulder, Colo. Re-instatement.

SIMRALL, HARRY C., Instructor in Drawing, Mississippi State College, State College, Miss. M. L. Freeman, L. L. Patterson.

SMAIL, LLOYD L., Professor of Mathematics, Lehigh University, Bethlehem, Pa. H. G. Payrow, Hale Sutherland.

SMELLIE, EDWIN F., Assistant Professor of Mechanical Engineering, University of New Mexico, Albuquerque, N. M. M. E. Farris, Chester Russell.

SMITH, E. D., in charge of Economics and Industrial Administration, Pratt Institute, Brooklyn, N. Y. H. E. Bean, R. B. Dale.

SOLLENBERGER, NORMAN J., Instructor in Applied Mechanics, Kansas State College, Manhattan, Kansas. M. A. Durland, C. H. Scholer.

STEPHENSON, LEONIDAS D., Instructor in Civil Engineering, University of Maine, Orono, Me. W. J. Creamer, W. J. Sweetser.

THOREN, THEODORE R., Assistant Professor of Mechanical Engineering, State University of Iowa, Iowa City, Iowa. A. H. Holt, H. O. Croft.

UHLER, EUGENE H., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. H. G. Payrow, Hale Sutherland.

VAGTBORG, HAROLD A., Associate Professor of Municipal and Sanitary Engineering, Armour Institute of Technology, Chicago, Ill. L. E. Grinter, H. T. Heald.

WALKER, SAMUEL B., Instructor in Civil Engineering, University of Idaho, Moscow, Ida. Ivan C. Crawford, R. H. Hull.

WILLIAMS, GORDON C., Assistant Professor of Chemical Engineering, University of Louisville, Louisville, Ky. R. C. Ernst, B. M. Brigman, W. B. Wendt.

YELLOTT, JOHN I., Assistant Professor of Mechanical Engineering, Stevens Institute of Technology, Hoboken, N. J. Jas. Creese, G. W. Barnwell.

CORRECTION

It would be appreciated if the following correction would be made in the report on "Manufacturing Processes."

Professor Dorrans of the University of Wisconsin closed the discussion with the statement that the discussion showed great dissension on the subject under discussion, that of giving foundry instruction. He stated that those engaged in teaching engineering economy seemed to know as little about their job as those teaching shop laboratory work seemed to know about theirs.

R. L. SWEIGERT

AMERICAN ASSOCIATION OF ENGINEERS

The Board of Directors of the American Association of Engineers in annual meeting in Chicago, November 8, 9, and 11, reviewed achievements of engineering societies as observed and reported by members of the Public Relations Committee of the Whole, and selected those that they considered outstanding for the year.

We enclose a copy of a resolution which indicates that the Society for Promotion of Engineering Education was cited for effective services in behalf of the engineers as businessmen and citizens, and the advancement of the public relations of the profession.

"Society for Promotion of Engineering Education which through its president C. C. Williams expressed the importance of development in the engineering schools of a combined course in engineering fundamentals and business practice and economics for training public works officials, industrial executives and liaison officers to correlate technology and sociology."

M. E. McIver,
Secretary.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

On October 22, 1936, the trustees of the Carnegie Corporation of New York resolved that "the sum of $16,000 be, and it hereby is appropriated to the Carnegie Foundation for the Advancement of Teaching, toward support of the program of the Engineers' Council for Professional Development."

Continued Carnegie interest in engineering activities is thus once again evidenced. It began in 1903 with a donation of $1,050,000 by Mr. Carnegie for erection of the Engineering Societies Building at 33 West 39th Street, New York City. In later grants the Carnegie Corporation has generously supported the Society for the Promotion of Engineering Education in its investigation of engineering schools extending over a period of five years as well as the summer schools for engineering teachers instituted and maintained by that organization.

The present $16,000 grant is made in support of the work of the Engineers' Council for Professional Development (E. C. P. D.) for the year October 1, 1936, to September 30, 1937. Additional appropriations in the amount of $3450 have been made to Council by the Engineering Foundation. Rental cost for Council's office recently opened in the Engineering Societies Building is expected to be met by three of the participating societies, the American Society of Mechanical Engineers, the American Society of Civil Engineers, and the American Institute of Electrical Engineers. Including this rental value a total fund of over $21,000 is available, of which $19,450 will be applied directly to the advancement of Council's program for enhancing the professional status of the engineer through the coöperative support of the national organizations directly representing the professional, technical, and legislative phases of the engineer's life.

SECTIONS AND BRANCHES

The **Colorado-Wyoming Section** held a meeting at the University of Wyoming on November 14, 1936. The members and guests were welcomed by Dean R. D. Goodrich. Following the welcome, the following papers were presented during the morning session:

"The History of Pumping," by Prof. R. W. Morton, Head of Mechanical Engineering Department, Colorado School of Mines.

"The Preparation in Mathematics of High School Students for Engineering Courses," by Prof. Charles A. Hutchinson, Head of Department of Engineering Mathematics, University of Colorado.

"The Preparation in English of High School Students for Engineering Courses," by Prof. W. Otto Birk, Professor of English, University of Colorado.

"The Preparation of High School Students in Wyoming for the Courses in Engineering," by Mr. A. A. Slade, Superintendent of Schools, Laramie, Wyoming.

At the close of the morning meeting, the Engineering laboratories and the campus buildings were inspected. Luncheon was served for members and guests, including the wives.

During the afternoon session the following papers were given:

"The Preparation of High School Teachers at the University of Wyoming," by Dean C. R. Maxwell, Dean, College of Education, University of Wyoming.

"Preparation of High School Graduates for the Work Offered at Colorado State College," by Dean E. B. House, Dean of Engineering, Colorado State College.

"Preparation of Indiana High School Graduates for the Work Offered at Purdue University," by Prof. Dudley P. Craig, Head of Mechanical Engineering Department, Colorado State College.

"Review of Employment Status of Recent Engineering Graduates of the University of Wyoming," by Prof. H. T. Person, Civil Engineering Department, University of Wyoming.

Following the talks and discussion of the afternoon session the routine business was completed. The invitation to hold the next

Annual Meeting during the spring of 1937 at Colorado State College, Fort Collins, Colorado, was accepted.

The following officers were elected for the year 1936–37:

President—Dean E. B. House,
Secretary—Prof. Dudley P. Craig.

The **University of Detroit Branch** met in Room 114, Engineering Building, November 12, 1936, with Professor B. N. Blakeslee, presiding.

Dean Freund announced that General Robert I. Rees wished to meet with the Deans and Professors from colleges in this area at two P.M. Thursday, November 19, in The Detroit Edison Building. The purpose of the meeting, Dean Freund stated, was to discuss matters pertaining to the proposed visit of the Committee on Engineering Schools appointed by the Engineer's Council for Professional Development.

Father John F. Quinn continued his discussion of the Committee's report on "Teaching Devices." Commenting on quality of work Fr. Quinn expressed a preference for grading as satisfactory or unsatisfactory. He also stated that, in his opinion, research men should confine their efforts to research work and should not attempt to teach as their training is confined to a limited portion of a field and is not broad enough for teaching. Father Quinn commended the Committee on the preparation of a splendid report, briefly expressed and containing many suggestions that can well be adopted by any teacher.

C. C. JOHNSTON,
Secretary.

The **Minnesota Section** of the S. P. E. E. held its first meeting of the year on November 23, 1936, in the Union building on the Minneapolis Campus, University of Minnesota.

President W. H. Kirchner presided at the meeting. Dinner was served at 6 P.M. Dr. Dowdell reported for the Program Committee. Walter S. Olson, Director, Division of Drainage and Waters, Minnesota Department of Conservation spoke on the subject "Water Conservation in the state of Minnesota."

Fifty-two members were present.

A. J. SCHWANTES,
Secretary.

On November 13, the **Newark College of Engineering Branch** held its first meeting to discuss Edward G. Baker's paper on Student Habits.

The discussion seemed to revolve about four points which might be stated as follows:

1. The ability to read and study a technical textbook.
2. The ability and possible suggestions for developing and improving concentration.
3. The relative merits of note taking.
4. Discussion of "how to study" books.

Concerning point one it seems that it is felt that previous to entering college the student has not had studies of a degree of difficulty necessary to compel him to read and study a textbook In an engineering college in addition to the ability to read is added the necessity for understanding and interpreting the nomenclature which is an added burden and perhaps helps to explain the ordinary student's apparent difficulty.

The discussion on concentration and the ability to concentrate was felt to be a more or less personal proposition. Different men can and do concentrate under varying conditions. In some cases isolation from all disturbing factors such as radios and persons is absolutely necessary. Others felt that thought was stimulated by such things as a radio program and perhaps a periodic interruption of study. Apparently then, in cases where a student is unable to concentrate, he may be aided by trying to determine under what set of conditions he can most advantageously work. It was felt that abstracting would aid the student in concentrating.

In the matter of taking notes, it seems that it was felt that in time a student could develop the ability to take notes and not lose the trend of the lecture. In this discussion a novel method was described in which the lecturer stopped periodically to permit the students to take notes on the material that had been given during that period. He was not permitted to take notes while the lecture was in progress.

Everyone seemed to feel that the use of "how to study" books was not particularly advantageous in that in most cases to study these texts would require the use of another book explaining the requirements necessary to study the "how to study" books.

The next meeting of the Branch will be held on December 18, at which time Mr. Baker's paper on "The Problem Method in an Engineering School" will be discussed.

PAUL E. SCHWEIZER,
Secretary.

The officers of the **Ohio Section** are: *Chairman*—H. W. Bibber, Ohio State University; *Vice Chairman*—R. C. Durst, University of Akron; *Secretary*—S. A. Harbarger, Ohio State University.

In a very tentative way it appears that the Section is likely to hold its annual meeting on April 17, 1937, in Columbus. This date is subject to confirmation at a later time.

H. W. BIBBER

The officers of the **Texas Section** for 1936–37 are: J. A. Correll, The University of Texas, *President;* Sophus Thompson, Southern Methodist University, *Vice-President;* and R. E. Lewis, Southern Methodist University, *Secretary.*

C. W. CRAWFORD

COLLEGE NOTES

The college of engineering of the **University of Alabama** has recently undergone considerable expansion in both physical equipment and teaching personnel. A large building has just been completed for laboratory and classroom instruction in hydraulic, mechanical, and aeronautical engineering. The moving of these departments has not only provided them with more modern facilities but has also allowed expansion of the departments left in Comer Hall, the old engineering building. The United States Bureau of Mines has just moved its Southern Experiment Station into a new building erected on the campus and has vacated space in Comer Hall which it has occupied for fifteen years. This move will provide space for the expansion of the laboratories of the Alabama School of Mines. A new wing has been added to the Chemistry Building, providing space for a new chemical engineering laboratory.

William J. Miller, head of the department of electrical engineering, and Otto H. Lunde, head of the department of aeronautical engineering, were added to the faculty in the fall of 1936. Professor Miller, a graduate of the University of Texas and the Massachusetts Institute of Technology, came to the University from the University of North Carolina where he was acting dean of the college of engineering. Professor Lunde, a graduate of New York University and a Lieutenant in the United States Naval Reserve Corp, was an instructor of aeronautical engineering at the Hillyer School, Hartford, Connecticut.

University of Colorado.—At the close of the University last June, Professor John A. Hunter retired after thirty-two years of active service in the College of Engineering. Coming to the University in 1904 as assistant professor, he was promoted in 1906 to a full professorship and to the headship of the Mechanical and Chemical Engineering Department. Professor Hunter has been a member of S. P. E. E. since 1905, and has been a full member of the American Society of Mechanical Engineers since 1914. He is an honorary member of both Tau Beta Pi and Alpha Chi Sigma. In December, 1932, he was elected to serve a two-year term as a Manager of the American Society of Mechanical Engineers; and in December, 1935, he was chosen vice-president of this organization, a position which he now holds.

Following Professor Hunter's retirement, the departments that he headed were separated into two distinct departments. The

new head of the Department of Mechanical Engineering is Professor Siebelt L. Simmering, who has for some years been Professor of Mechanical Engineering in this college. Previously he taught at the University of Illinois, Pennsylvania State College, and the Kansas State College. He is a member of Tau Beta Pi and of the American Society of Mechanical Engineers.

The new head of the Chemical Engineering Department is Henry L. Coles, who came to the University this fall from the University of Detroit, where he was for three years head of the Department of Chemical Engineering. Dr. Coles holds a B.S., a Ph.D., and a Ch.E. degree from Ohio State University, and an M.S. degree from Rose Polytechnic Institute. In addition, he took two years of graduate work in Columbia University. He has taught in the Rose Polytechnic Institute, Columbia University, the College of the City of New York, and the University of Detroit. Moreover, he has held several important positions in industry, including that of research engineer for Proctor and Gamble; chief metallurgist and chemist for the Niles-Bemet-Pond Company; and research enginer for the Mosler Safe and Vault Company, of which he was for several years vice-president. Dr. Coles is a member of Sigma Xi, and has been a member of the American Institution of Chemical Engineers since 1924.

Because of serious illness, Professor Frank G. Allen has retired after many years as head of the Department of Mechanical Drawing. This department now includes the courses in machine design, and is headed by F. S. Bauer, who has been Professor of Machine Design in the Department of Mechanical Engineering.

This fall the College of Engineering had an unexpectedly large increase in the whole student body, with nearly fifteen per cent more students than the preceding fall.

University of Idaho.—J. E. Buchanan of the Civil Engineering department has been given a year's leave of absence to become Technical Research Engineer for The Asphalt Institute, Pacific Coast Division, with headquarters at 206 Sansome Street, San Francisco. To partly fill the vacancy left by Professor Buchanan, Frederick E. Drager, former Director of Water Resources, Idaho Department of Reclamation, was added to the faculty as instructor in Civil Engineering. William Schroeder has been raised to the rank of Assistant Professor in Mechanical Engineering and Branch Walker and Stanley Hall, both graduates of this institution, have been added to the faculty as instructors in Civil Engineering and Mechanical Engineering respectively.

Present enrollment in the College of Engineering is 313, a twelve per cent increase over last year and a sixty per cent increase over the pre-depression years of 1927, 28, and 29.

Massachusetts Institute of Technology.—Illuminating engineers of the Department of Electrical Engineering have completed an extended research program upon the problems of highway lighting. The program was instigated two years ago as a CWA–ERA project. In this project, known as the Massachusetts Highway Accident Survey, some 5000 field tests, taken under actual driving conditions, were made.

In order to fit the results of this project to a form more adaptable to practical use, a miniature highway was designed and built in the Illumination Laboratories. This model has proved its worth in studying the effect of lamp size, mounting height, type of pavement, and the relative importance of glare. It is operated in a room lighted only with the lamps of the model where an observer's "car," a vehicle much like a wheel chair, approaches the model at a definite speed. The distance between the model and the point at which the observer could first discern the gap in a "C" test object (International "C" object) was used to indicate different conditions of visibility. 15,000 tests made by seven observers have shown that a rough macadam requires about ten times as much light as does a concrete surface, whereas a smooth macadam requires three times as much light as the concrete.

During the past summer the Department of Physics has featured a special program in applied physics which included two conferences, one on spectroscopy and the other on color. At these conferences, held July 20–July 25, the color conference following immediately upon the closure of the conference on spectroscopy, papers were presented and discused on many of the problems existing in these two closely-related fields. Members of the staff of the Institute delivered three of these papers at the conferences.

Dr. Harry Woodburn Chase, chancellor of **New York University** announced the promotion of Professor Sampson K. Barrett, of the College of Engineering, to assistant dean of the College, in charge of Evening Engineering Division. Dean Barrett, who is a professor of electrical engineering, has been a member of the faculty since 1919. Previously he had been a member of the faculty of the Polytechnic Institute of Brooklyn from which he graduated in 1910. During the past ten years he has devoted most of his attention to the Evening Engineering Division of the University which, under his direction, increased its enrollment from 436 students in 1926 to 1163 last year.

Other promotions in the College of Engineering were those of Associate Professor Lewis Van Carpenter to professor of sanitary engineering, and Paul C. Cromwell, from instructor to assistant professor of electrical engineering.

The University of North Dakota.—In keeping with new advances in the field of engineering, the faculty of the College of Engineering recommended a complete revision of the engineering curricula, effective with the beginning of the present school year. This revision was studied by a faculty committee of representatives of each department of the college and was put into effect in September, 1936. Of major importance were the changes made in the freshman and sophomore years. Heretofore, the curricula for the first two years were the same for all branches of engineering. The present revision provides a common curriculum only for the freshman year. Specialization then begins with the sophomore year.

A recent visit to the campus by Mr. Charles W. Boise of London, England, resulted in his establishing a trust fund in the amount of $10,000 for the continued support of five scholarships for engineering students attending the University. The recipients of these scholarships are chosen by a faculty committee on the basis of scholarship, interest in engineering activities at the University, and character. Mr. Boise graduated from the College of Engineering of the University in 1908. He is associated with Selection Trust, Ltd., London.

A long needed improvement to the department of Chemical Engineering has been made possible through federal assistance in the construction of a fire-proof laboratory building. This building was constructed under the W.P.A. program in the state and is of concrete and brick construction. Inside dimensions of the building are 30 feet by 40 feet with a 25-foot head clearance. Chemical Engineering equipment now housed in the School of Mines building will soon be moved to the new laboratory. Certain additional equipment to be built with available labor under supervision of staff members.

J. H. Arnold, who received his undergraduate training at the University of Minnesota and his graduate training at Massachusetts Institute of Technology, has joined the Chemical Engineering staff of this college.

For the past three years the College of Engineering has actively coöperated with the federal government in providing work for skilled white collar workers. At the present writing seven research projects are in progress which have provided work for 105 persons including graduate engineers, chemists, and others. Among these studies are: Lignite Utilization Survey, Lignite Drying Investigation, Ceramic Survey, Brick and Tile Investigation, Soil for Building Material Investigation, Activated Carbon Study, Mines of North Dakota. (Their sampling and survey.)

Northeastern University.—Four new appointments to the faculty of the College of Engineering have been announced by Dean Carl S. Ell.

George Baker Welch has been appointed Assistant Professor of Physics. He was graduated from Bowdoin College, Magna Cum Laude, in 1922 and subsequently studied at Yale University and Cornell University, receiving his Ph.D. degree from the latter institution in 1928. Since that time he has been a teacher of Physics at Williams College, Cornell University, and Wells College. For the past year, Dr. Welch has been working on a translation of Hass' "The World of Atoms."

Charles A. Sewell, who has been appointed Instructor in Mathematics, received his B.S. degree in 1929 and his M.S. degree in 1932, both from the University of New Hampshire. Since his graduation, Mr. Sewell has served as Head of the Mathematics Department in the Dover High School in Dover, N. H., and as Instructor in Mathematics at the University of New Hampshire.

Otis French Cushman has been appointed Instructor in Drawing. He holds the degrees of B.S. and M.S. from the University of New Hampshire and has served as Acting Head of the Physics Department of the Portsmouth, N. H., High School. More recently he has been a research assistant in the Agricultural Engineering Department of the University of New Hampshire.

The Department of English has been augmented by the appointment of Franklin Norvish, a graduate of Colby College with the degree of B.S. and of Yale University with the degree of M.A. Mr. Norvish is a member of Alpha Tau Omega and Kappa Phi Kappa fraternities.

The Ohio State University.—E. A. Hitchcock, for nineteen years Dean of the College of Engineering and Director of the Engineering Experiment Station, has been given the title of Dean Emeritus. He graduated with the degree M.E. from Cornell University in 1890, and after three years in industry joined the Department of Mechanical Engineering at The Ohio State University, where he rose through successive grades to Professor of Experimental Engineering. He resigned in 1913 to enter industrial work in a management capacity, and returned in 1920 as Dean. The Trustees have appointed William D. Turnbull as acting Dean and J. M. Weed as acting Junior Dean.

Dean Turnbull, graduated in 1908 with the C.E. degree, and entered practice of this profession. He was made Instructor in Engineering Drawing in 1910 and Professor and Secretary of the College of Engineering in 1923. When the position of Junior Dean was created in 1928 in the five largest colleges to take charge

of the personnel and adjustment problems of freshmen and sophomores, Mr. Turnbull was selected to fill it.

Mr. Weed received his A.B. degree in 1921 and was an instructor in English prior to receiving his B.C.E. in 1926. He became associated with the Engineering Experiment Station in 1927 becoming Assistant Director and Associate Professor of Civil Engineering in 1935.

J. R. Shank, Research Professor of Civil Engineering is Acting Assistant Director of the Engineering Experiment Station. He is a graduate of Pennsylvania State College in 1910 and has been connected with the Department of Civil Engineering and the Engineering Experiment Station in various capacities since 1917.

David Helm, Research Engineer who has been engaged on metallurgical research resigned September 15 to take a similar position with the Mellon Institute. William H. Lenz has been appointed to fill this vacancy.

George A. Loomis, Assistant Professor who has been on leave of absence has returned to active duty at the Experiment Station. He is engaged in Ceramic Research.

Professor M. L. Pool, of the Department of Physics and Astronomy has been awarded the Elizabeth Clay Howald Scholarship for the year 1936–37. This scholarship makes it possible for Dr. Pool to devote the entire year to research work in the field of nuclear physics in which he has for some time been interested. He has been granted a leave of absence for one year and will now be able to carry on his research work on nuclear physics more effectively.

Wilson M. Brubaker and Howard A. Robinson have been appointed instructors in physics for the year 1936–37. They will carry on the teaching duties and supervision of research normally assigned to Dr. Pool. Dr. Brubaker has just been awarded the Ph.D. degree by the California Institute of Technology. He is the author of a number of papers on nuclear physics. Dr. Robinson received his Ph.D. degree from the Massachusetts Institute of Technology and came directly from the University of Uppsala where he was working in the spectroscopic laboratory of Professor Siegbahn. His chief interests are in spectroscopy.

Earle S. Ebers, who was awarded a Royal Canadian Fellowship for the year 1936–37 has elected to come to the Department of Physics to do research work in the field of infrared spectroscopy. Last year Dr. Ebers completed the work for the Ph.D. degree at Harvard University. He is especially interested in the physical and chemical properties of formaldehyde. In his research work here he will collaborate with Professor H. H. Nielsen of the Physics

Department who is nationally known for his work in the field of infrared spectroscopy.

Laurie J. Rautio has been added to the staff of the Department of Metallurgy as an Instructor. Mr. Rautio graduated from the Department of Metallurgy of The Ohio State University in 1931 and since then has been in the Metallurgical Department of the American Rolling Mill Plant at Ashland, Kentucky, with extensive experience in the metallurgy of sheet steel making.

U. W. Denman, Instructor in pattern making, Department of Industrial Engineering, died suddenly in May 1936. He had been on the staff since 1908. He is succeeded by Harold M. Poole who graduated with a B.S. in Ed. degree, spent four years with Westinghouse E. & M. Co., and taught in high schools prior to joining the staff in June to take charge of the work during the Summer Quarter.

Through the efforts of Professor Peter Morrison and others the Warner and Swasey Company of Cleveland has consigned to the Industrial Engineering Department one of their new Universal Turret Lathes with all accessories, adding greatly to the flexibility of the machine shop.

Paul Lehoczky has announced the establishment of a Motion Study Laboratory including work benches, projects, projector and other equipment for the use of the students in Industrial Engineering.

James E. Boyd, for thirty years Professor of Mechanics has been made Emeritus professor. He received his B.Sc. in 1891 from Ohio State University and an M.S. from Cornell University in 1896. Before the Department of Mechanics was established he was Assistant Professor of Physics and later Associate Professor of Mathematics. At his own request he relinquished his duties as chairman of the department in 1934 and was succeeded by P. W. Ott in order to devote his full time to teaching.

All records of enrollment have been broken with more than 12,000 students registered for the Autumn Quarter. Freshmen exceed 3400 with 594 of these being engineers. The Engineering College has 1878 students, 1717 of whom are taking strictly engineering work and 164 Applied Optics.

In the Department of Chemistry, G. Bryant Bachman has resigned to join the research staff of the Eastman Kodak Co. Due to the unprecedented enrollment in first year chemistry (2035 students) several new appointments were necessary: John P. Howe, A.B. Hobart University, 1933; Ph.D. Brown University, 1936. He holds a National Research Council Fellowship for 1936–37. Wm. MacNevin, A.B. Mount Allison University, 1927; A.M. Harvard University, 1930; Ph.D. University of Minnesota 1936. He was

formerly an Instructor at Harvard and at Mount Allison. Melvin S. Newman, B.S. 1928, Ph.D. 1932. He held a National Tuberculous Fellowship at Yale University in 1932–33; a National Research Council Fellowship in 1933–34 at the College of Physicians and Surgeons, and the Eli Lilly Fellowship at Harvard University in 1934–36. Frank H. Verhock, A.B. Harvard University, 1929; Ph.D. University of Wisconsin, 1933; Rhodes Scholar, Oxford University, 1935; Rhodes Scholar, Institute for Chemical Physics, Copenhagen, 1935–36.

Dean Wm. McPherson formally retired from his position as Dean of the Graduate School 1st June last pending the selection of his successor he will continue his duties. He has served in this capacity since the formation of the Graduate School in 1911.

Professor W. R. Brode of the Chemistry Department was a member of the Harvard M. I. T. Astronomical Expedition into Russia. The weather conditions prevailing at the moment of totality of the eclipse were ideal for the purpose which Professor Brode had in mind. After having made these astronomical observations, in which he was assisted by Mrs. Brode, who is a physicist, they visited many of the Russian universities. Later in the summer Dr. Brode represented the National Research Council of the United States, as a delegate to the meeting of the International Union of Chemistry.

The E. I. duPont de Memours and Company recently established four research associateships to be placed in four universities of this country for the purpose of enabling young investigators of promise to carry on their research programs in the highest possible efficiency. Among the four selected was Professor M. L. Wolfrom who was chosen by reason of his distinguished contributions to Carbohydrate Chemistry.

Practically every department of the Enginering College has been called upon by industries and various governmental bureaus for more men than could be furnished. In some fields there appears to be a definite shortage of available competent men. It is to be hoped that this will encourage better initial salaries and working conditions.

David C. Williams has been appointed Instructor in Mechanics. He received his B.S. from the University of Oregon in 1932. A Rhodes Scholarship took him to Oxford University where he studied engineering under Professor R. V. Southwell. He received his B.A. "First Class" in 1935 and M.S. in C.E. at Columbia University in 1936 where he was a Bridgham Fellow from the University of Oregon.

University of Pennsylvania Moore School of Electrical Engineering.—Beginning with the year 1937–1938, two options will be

offered in the undergraduate course in Electrical Engineering. One option, known as the Research and Development Option, is designed primarily for those students who wish to prepare themselves to take up the more technical side of electrical engineering, such as research and development work with manufacturing organizations and public utilities.

The other option, known as the Industrial Option, offered for those students who enter in 1936 and subsequently, is designed for students who wish to prepare themselves for the less technical positions in the electrical industries, such as sales engineers, construction engineers and general purpose engineers in public utilities and manufacturing companies.

Professor John Grist Brainerd, who was on leave of absence during the year 1935–1936, has resumed his teaching at the Moore School. While on leave of absence, Professor Brainerd was associated with the Public Works Administration as an Engineer in the Power Division.

During the summer, the Differential Analyzer in the Moore School was used by several engineers from one of the large electrical manufacturing companies in the study of the effects of magnetic saturation on electric circuits.

The evening graduate courses, which were inaugurated in the Moore School in 1929, continue to grow in favor with the electrical engineers employed in Philadelphia and its vicinity. Sixty-five such men, each of whom holds a Bachelor degree, are taking evening graduate work in the Moore School this year. The following evening courses are offered: Engineering Physics, Atomic Theory, Electrification of Industrial Plants, High Frequency Alternating Currents, Higher Mathematics in the Solution of Engineering Problems, Industrial Management and Business Administration, Differential Equations, The Experimental Basis of Modern Physics.

University of Toledo.—A new study-practice plan for seniors in Engineering has recently been devised and put into effect by Delos M. Palmer, Dean of Engineering, and L. H. Middleton, Chief Engineer, the Auto-Lite Company. Selected upperclassmen are given the opportunity to do advanced study in the Auto-Lite research laboratories under the supervision of University faculty members and Auto-Lite engineers. The plan calls for two afternoons of special work weekly in the company laboratories, at a standard hourly rate of remuneration, and academic credit, which may be awarded on the basis of student reports and general industrial ability. Nine senior students are, at present, taking the new course, in addition to their conventional technical studies.

The University of Wyoming.—The enrollment this year in the Engineering College represents the largest in its history with a 36 per cent increase over that of last year.

R. D. Goodrich, Dean of Engineering, and Professor of Civil Engineering, spent the summer in Portland, Oregon, as consulting engineer on flood control investigations with the North Pacific Division of the United States Army Engineers. He will be engaged part time on this same work during the coming year and will make intermittent trips to Portland.

L. W. Collister has been added as an assistant in the Mechanical Engineering Drawing Department.

Due to the large increase in enrollment a new drafting room will be opened, which will be equipped with twenty drafting tables, stools, lockers, etc.

H. T. Person, Professor of Civil Engineering, was in charge of water resources studies in Wyoming for the Wyoming State Planning Board.

A. J. McGaw, Instructor in Civil Engineering, was employed by the Wyoming State Highway Department at Cheyenne, Wyoming, during the past summer.

The Mechanical Department has designed and built a photoelasticity polariscope and this present school year the instrument is being used in a research problem of determining the distribution and magnitude of stresses in gear teeth. This department, which has charge of the shop work in the University here, is adding several pieces of machinery to the equipment of the Shops department this year. One of the senior students is conducting a research problem on native materials for use in the installation of houses, refrigerators, etc.

The Electrical Department is equipping its laboratory with several new meters, and instruments necessary for class and research work.

BOOK REVIEW

Electrical Engineers Handbook. PENDER AND DEL MAR. Third Edition. Vol. IV. Electric Power. John Wiley and Sons. $6.00.

The third revised edition of Pender's Electrical Engineers' Handbook appears in a new form. Material fundamental to all engineering has been removed to another separate volume, while the Electrical Engineering material has been divided into two volumes, one dealing with *"electric power"* and the other with *"Electric Communication and Electronics."* The encyclopedia arrangement has been abandoned for a more *practical* sequence of topics.

The Electric Power, Volume IV, has been consolidated into nineteen sections, each dealing with a general topic. Many new topics such as Air-conditioning, Electric Water-heating and Electricity in Agriculture, have been included. Power transmission and distribution has been given a comparatively large amount of space. Automotive Electrical Engineering and Industrial application of Motors, have been given somewhat more prominence than some other topics. Each of the nineteen sections has been edited by an expert on the topic. The section headings include: Mathematics; Units and Symbols; Properties of Materials; Electric Circuits and Electric Lines; Resistors; Reactors; Magnets; Measurements and Measuring Apparatus; Principles of Electrochemistry; Batteries; Direct-current Machines; Alternating-current Machines; Transformers; Converters and Rectifiers; Switching Control and Protection; Power Stations and Sub-stations; Power Transmission and Distribution; Lighting and Heating; Industrial Applications of Motors; Transportations; Electrochemical and Electrothermal Industries; Electricity on the Farm.

It is to be noted that "Pender" is now in two volumes. *"Electric Power,"* Volume IV, is intended for those engineers in that field, while the Volume V, *"Electric Communication and Electronics,"* is written for those other engineers interested in that field.

R. C. GORHAM

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FRANK A. HEACOCK, EDITOR

A Journal of Engineering Drawing

At the Madison meeting in June 1936, the Division of Engineering Drawing agreed that there is a need for a publication devoted to the interests of teachers of engineering drawing and descriptive geometry. As a means for the publication of papers and discussions presented at meetings of the division, as an official journal for articles of a technical nature on engineering drawing and descriptive geometry, and the teaching of these subjects, such a journal, it was agreed, would be not only the means of preserving and distributing such articles but also—and this was especially emphasized—of illustrating them and of publishing other material requiring illustration for proper presentation. At a subsequent meeting of the Executive Committee of the division, the publication of a journal of engineering drawing was authorized and a publication committe consisting of F. G. Higbee, John M. Russ, and Clair V. Mann was appointed with power.

This publication committee has now agreed upon a policy of publication as follows: There will be at least three issues per year; the subscription price will be $3.00; the first issue will appear before Jan. 1, the second issue in May, and the third issue in the fall of 1937. Material of interest is solicited: problem material; interesting examination presentations; drawings of merit and containing interesting teaching points; articles on methods of teaching and administration are to be submitted to the publication committee.

Teachers of engineering drawing and descriptive geometry, and others who wish copies of the first issue are requested to send their name and mailing address at once to F. G. Higbee, 204 Electrical Engineering Bldg., Iowa City, Iowa, the chairman of the publication committee. The first issue will contain a resume and the papers of the Madison meeting of the division, and other material of interest.

This journal is supplementary to the T-Square Page and does not supplant it in any way.

Drawings for the National Drawing Competition for 1937 of the Drawing Division will be exhibited at Cambridge, Mass., in June 1937. For specifications and entry numbers write to Carl L. Svensen, Box 933, Lubbock, Texas.

ENGINEERING ENROLLMENTS, 1936–37

150 institutions giving instruction in engineering were requested to furnish the following information. 119 had replied as of December 7, 1936, 115 in the United States and 4 in Canada.

SUMMARY OF UNDERGRADUATE ENROLLMENTS IN 119 ENGINEERING SCHOOLS IN 1936–37

115 Schools in United States

Engineering Courses	No. of Persons Teaching Course	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others (Please name)	Totals	No. of First Degrees Conferred During the Academic Year 1935–36
Aeronautical.....		398	399	315	215	22	5	——	1	1,355	
Agricultural.....		269	280	147	120	3	3	——	——	822	
Architectural.....		304	241	179	138	32	6	——	——	900	
Ceramic.....		144	130	74	48	——	55	——	——	451	
Chemical.....		2,730	2,895	2,300	1,688	81	47	534	1	10,276	
Civil.....		1,809	1,952	1,875	1,506	55	54	485	1	7,737	
Electrical.....		2,513	2,742	2,440	1,914	75	62	929	3	10,678	
Industrial.....		318	457	359	338	6	5	89	——	1,572	
Mechanical.....		3,327	3,688	2,909	2,247	92	70	855	2	13,146	
Metallurgical.....		258	297	272	196	3	7	221	——	1,254	
Mining.....		327	329	252	196	4	12	——	——	1,120	
Unclassified.....		7,835	719	240	208	——	71	2,064	431	11,568	
Others.....		1,012	1,074	904	623	6	27	20	——	3,666	
General		1,804	639	262	232	——	3	30	——	2,970	
Totals (118 Institutions).....	3,732	23,058	15,842	12,528	9,669	379	427	5,227	439	67,569	*7,881
Totals 1935–36 (124 Institutions)....		20,128	14,821	12,031	10,436	363	322	5,814	222	66,541	†8,847

* 103 Institutions reporting. † 106 Institutions reporting.

Totals 1935–36 (124 Institutions)		20,128	14,821	12,031	10,436	363	322	5,814	222	66,541	†8,847

* 103 Institutions reporting. † 106 Institutions reporting.

Summary of Undergraduate Enrollments in 119 Engineering Schools in 1936–37

4 Schools in Canada

Engineering Courses	No. of Persons Teaching Course	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Sutdents	Totals	No. of First Degrees Conferred During the Academic Year 1935–36
Aeronautical		—	—	—	—	—	—	—	
Agricultural		—	2	2	2	—	—	6	
Architectural		4	2	6	8	12	—	32	
Ceramic		—	2	3	—	—	—	5	
Chemical		90	99	66	65	—	—	320	
Civil		109	104	48	57	41	—	359	
Electrical		54	43	33	40	—	—	170	
Industrial		—	—	—	—	—	—	—	
Mechanical		52	45	77	56		—	230	
Metallurgical		47	32	26	13	—	—	118	
Mining		138	84	70	45		—	337	
Unclassified		138	—	—	—	—	4	142	
Others		12	7	6	—	—	—	25	
Totals	179	644	420	337	286	53	4	1,744	284

Undergraduate Enrollment by Institutions

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred n 1935–36
Akron U.	6	6	23	24	18	1	——	——	78	21
Ala. Poly.	183	165	129	106	——	——	——	——	583	109
Ala. U.	241	138	118	108	——	8	——	3	616	——
Ariz. U.	97	68	75	44	——	9	——	——	293	35
Ark. U.	100	80	58	32	——	——	——	——	270	24
Armour Inst.	338	168	141	157	——	34	1,244	——	2,082	144
Alaska U.										
Brooklyn P.	114	126	104	98	——	——	920	——	1,362	122
Brown U.	53	39	23	20	——	——	——	——	135	22
Bucknell U.	74	46	19	30	——	2	——	——	171	30
Calif. U.	262	280	454	378	——	36	——	——	1,412	255
Calif. U. L. A.										
Calif. Inst.										
Calif. U. So.	60	44	71	62	——	3	175	——	415	53
Carneg. Inst.	344	244	207	196	——	4	947	——	1,942	181
Case Sch.	237	206	147	117	——	20	430	——	1,157	115
Catholic U.	42	28	22	31	——	3	——	——	126	15
Cin. U.	415	316	200	126	109	2	224	——	1,392	128
Citadel	37	36	29	22	——	——	——	——	124	22
Clarkson C.	95	87	78	57	——	——	——	——	317	38
Clemson C.	262	171	110	49	——	1	——	——	593	51
Colo. Mines	193	180	150	71	——	——	——	——	594	——
Colo. Ag.	——	——	——	——	——	——	——	350	350	——
Colo. U.	249	149	119	117	——	——	——	——	634	94

Colo. Mines	199	156	136	72	——	——	——	——	563	——
Colo. Ag.	——	——	——	——	——	——	——	350	350	——
Colo. U.	249	149	119	117	——	——	——	——	634	94

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1935–36
Columbia U.	117	98	53	68	71	6	——	——	413	53
Conn. St. C.	34	14	14	6	——	——	——	——	68	12
Cooper U.	102	67	69	56	——	——	731	——	1,025	169
Cornell U.	316	218	200	173	8	——	——	——	915	179
Dartmouth	35	25	18	11	4	——	——	——	93	15
Dayton U.	70	48	22	16	——	——	——	——	156	29
Del. U.	73	48	27	25	——	2	——	——	175	26
Denver U.	47	40	25	17	——	——	——	——	129	15
Detroit U.	203	106	111	36	46	6	——	——	508	33
Drexel Inst.	284	175	125	79	80	——	——	——	743	69
Duke U.	45	45	18	32	——	1	——	——	141	20
Fla. U.	124	90	87	77	——	——	——	——	378	47
Ga. Tech.	559	438	431	213	——	5	——	——	1,646	178
Geo. Wash. U.	160	96	93	43	——	——	——	——	392	39
Gettysburg	18	7	10	4	——	——	——	——	39	3
Hawaii	25	23	11	9	2	——	——	——	70	14
Howard										
Idaho U.	147	110	90	51	——	——	——	——	398	57
Ill. U.	771	437	361	315	——	5	——	——	1,889	242
Iowa C.	531	376	212	206	——	6	——	——	1,331	178
Iowa U.	116	101	69	82	——	——	——	2	370	51
J. Hopkins										

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1935–36
Kans. C.	313	229	201	134	—	—	—	—	877	107
Kans. U.	173	153	153	119	—	8	—	—	606	79
Ky. U.	152	135	84	57	—	1	—	—	429	49
Lafayette	68	80	40	39	—	—	—	—	227	42
Lehigh	358	291	179	140	—	—	—	—	968	159
Lewis Ins.										
La. St. U.	587	214	149	101	—	8	—	—	1,059	89
Louisville	52	39	31	31	—	1	—	—	154	26
Maine U.	134	78	82	70	—	—	—	—	364	65
Manhattan	91	44	36	46	—	—	—	—	217	—
Marquette	147	98	160	55	—	4	—	—	464	72
Maryland	117	76	63	45	—	2	—	—	303	49
M. I. T.	544	459	411	365	—	13	—	—	1,792	341
Mich. Mines										
Mich. C.	—	153	118	105	—	—	—	—	376	89
Mich. U.	410	429	468	371	2	3	—	—	1,683	271
Minn. U.										
Mo. U.	155	88	66	59	—	—	—	—	368	48
Mo. Mines	171	116	95	91	—	—	—	—	473	—
Mont. C.	169	105	54	49	—	—	—	—	377	—
Mont. Mines	101	67	27	29	—	1	—	—	225	21
Miss. Univ.	23	17	10	6	—	—	—	—	56	10
Miss. C.	291	232	129	103	—	3	—	—	758	66

Miss. C.	291	232	129	103	—	3	—	—	758	66

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1935–36
Nevada U.	97	47	36	10	—	14	—	—	204	29
Nebr. U.	325	191	162	74	3	—	—	—	755	74
Newark C.	191	185	123	121	—	19	139	—	778	120
New H. U.	120	82	63	53	—	1	—	—	319	65
New M. U.	74	45	22	13	—	—	—	—	154	17
New M. A. M.										
New M. Mines	59	32	29	17	—	6	—	—	143	20
New York U.										
N. Y. C. C.										
No. Car. C.	402	193	142	89	—	—	—	—	826	—
No. Car. U.	—	—	39	31	—	—	—	—	70	30
No. Dak. C.	108	59	53	37	—	—	—	—	257	40
No. Dak. U.	84	61	40	23	1	52	—	—	261	26
No. East. U.										
No. West. U.										
Norwich	51	28	16	19	—	—	—	—	114	21
Notre Dame	161	110	81	56	—	—	—	—	408	57
Ohio No.	48	21	17	24	—	—	—	—	110	21
Ohio St. U.	600	532	335	253	15	2	—	—	1,737	195
Okla. A. M.	364	211	183	123	11	6	—	—	898	91
Okla. U.	360	272	277	184	—	10	—	—	1,103	110
Ore. C.	306	228	136	90	—	—	—	—	760	71
Pa. St. C.	454	397	267	190	—	—	—	—	1,308	209
Pa. U.:										
Towne Sci.	90	89	55	69	—	—	—	—	303	—
Moore E. E.	19	17	19	15	—	—	65	—	135	15

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1935–36
Pittsburgh	230	187	143	119	—	—	91	78	848	117
Porto Rico	97	50	26	26	—	52	—	—	251	45
Princeton	95	68	50	41	—	—	—	—	254	—
Purdue	1,216	832	579	393	—	10	—	—	3,030	373
Renss. P. I.	312	208	226	204	—	—	—	—	950	183
R. I. Coll.	81	70	69	40	—	—	—	—	260	43
Rice	183	105	64	50	—	—	—	—	402	48
Rose P. I.	82	44	38	27	—	—	—	—	191	36
Rochester	48	43	24	20	—	—	54	—	189	—
Rutgers	56	49	38	33	—	4	—	6	186	35
So. Dak. C.										
So. Dak. U.										
So. Dak. Mines	126	83	48	48	—	4	—	—	309	29
So. Meth. U.	95	21	30	12	—	—	—	—	158	20
Stanford U.	—	—	60	68	—	—	—	—	128	65
Stevens	174	123	97	103	—	—	—	—	497	82
Swarthmore	17	15	12	15	—	—	—	—	59	12
Syracuse	138	110	71	57	—	—	—	—	376	78
Santa Clara	23	19	8	10	—	—	—	—	60	6
Tenn. U.	276	127	64	41	—	2	—	—	510	—
Tex. A. M.	976	506	297	200	5	9	—	—	1,993	154
Tex. U.	444	332	264	181	—	—	—	—	1,221	87
Tex. Tech	248	109	78	75	—	—	—	—	510	37
Toledo U.	151	56	53	32	—	1	207	—	500	8

Tex. Tech	248	109	78	75	—	—	—	—	510	37
Toledo U	151	56	53	32	—	1	207	—	500	8

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1935–36
Tufts C	122	98	65	85	—	—	—	—	370	74
Tulane U	115	74	59	49	—	—	—	—	297	38
Union C										
Utah U	170	131	82	45	—	—	—	—	428	—
Valparaiso	30	13	7	5	—	—	—	—	55	—
Vanderbilt										
Vermont	42	22	22	20	—	—	—	—	106	32
Villanova	71	38	35	30	—	—	—	—	174	—
Va. Mil										
Va. P. I	500	291	181	172	—	1	—	—	1,145	165
Va. U	67	52	31	32	—	1	—	—	183	15
Wash. (St. L.)	132	88	71	49	—	26	—	—	366	60
Wash. U	650	268	238	210	—	4	—	—	1,370	113
Wash. C	216	151	126	91	—	—	—	—	584	57
W. Va. U	153	111	72	59	4	1	—	—	400	70
Wis. U										
Wyoming U	141	87	43	34	—	4	—	—	309	18
Worc. P. I	198	139	120	76	—	—	—	—	533	99
Yale U	235	78	63	47	—	—	—	—	423	—
United States	23,058	15,842	12,528	9,671	379	427	5,227	439	67,569	7,881

Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrese Conferred in 1935–36
CANADIAN										
Alberta										
Br. Col. U.										
Ecole P.	80	35	34	34	41	—	—	—	224	34
McGill U.										
New Bruns. U.										
Queen's U.	143	115	102	87	—	4	—	—	451	87
Sask. U.	138	65	47	30	—	—	—	—	280	25
Toronto U.	283	205	154	135	12	—	—	—	789	172
Canadian	644	420	337	286	53	4	—	—	1,744	284
United States	23,058	15,842	12,528	9,671	379	427	5,227	439	67,569	7,881
Grand Total	23,702	16,262	12,865	9,957	432	431	5,227	439	69,313	8,165

Institution	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Professional)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Ariz., Univ.	8	—	—	—	8	4	—	—	—	—	—	—
Ark., Univ.	2	—	—	—	2	—	—	—	—	—	—	—
Armour	7	—	144	—	151	6	—	—	—	—	—	—
Brooklyn	—	7	223	—	230	20	1	1	5	—	7	0
Brown Univ.	—	4	—	—	4	—	—	1	—	—	1	—
Bucknell Univ.	1	—	—	—	1	—	—	—	—	—	—	—
Calif. Univ. of So.	4	—	13	2	19	4	—	—	—	—	—	—
Carnegie	13	—	52	—	65	7	3	—	—	—	3	1
Case	2	27	—	—	29	4	—	—	—	—	—	—
Catholic Univ.	—	—	2	—	2	—	—	—	—	—	—	—
Cincinnati	1	—	—	—	1	2	—	—	—	—	—	—
Clarkson	2	—	—	—	2	1	—	—	—	—	—	—
Colo. Mines	2	1	—	—	3	—	—	—	—	—	—	—
Colo., Univ.	8	—	—	14	22	9	—	—	—	—	—	—
Cornell Univ.	51	—	—	1	52	Eng. 36* 26	27	—	—	—	27	5
Columbia	14	40	—	42	96	22	35	22	—	—	57	9
Florida, Univ.	8	3	—	—	11	2	—	—	—	—	—	—
Ga. Tech.	17	—	—	—	17	7	—	—	—	—	—	—
Idaho, Univ.	7	9	—	—	16	13	—	—	—	—	—	—
Illinois, Univ.	41	20	—	—	61	28	9	11	—	—	20	7

Enrollment of Graduate Engineering Students, 1936–37—Continued

Institution	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Professional)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Iowa St. Coll.	3	35	—	8	46	22	—	—	—	—	—	1
Iowa, Univ.	28	—	—	—	28	14	12	—	—	—	12	—
Kansas St. Coll.	2	13	—	1	16	6	—	—	—	—	—	—
Ky., Univ.	1	4	—	—	5	—	—	—	—	—	—	—
Lehigh Univ.	—	28	—	—	28	14	—	4	—	—	4	0
La. St. Univ.	18	17	—	—	35	7	2	—	—	—	2	2
Louisville, Univ.	3	—	—	—	3	4	—	—	—	—	—	—
Maine, Univ.	4	6	—	—	10	4	—	—	—	—	—	—
Manhattan Coll.	6	23	—	1	30	3	—	—	—	—	—	—
Marquette Univ.	—	2	—	—	2	—	—	—	—	—	—	—
Mass. Inst. Tech.	312	—	—	—	312	135	94	—	—	—	94	17
Mich., Univ.	127	15	—	6	148	82	9	27	—	1	37	20
Mich. St. Coll.	—	7	—	—	7	—	—	—	—	—	—	—
Miss. St. Coll.	—	—	—	—	—	1	—	—	—	—	—	—
Mo., Univ.	2	1	—	—	3	1	1	—	—	—	1	—
Mo. Sch. Mines	8	—	—	—	8	2 3*	3	2	—	—	5	—
Mont. Sch. Mines	12	—	—	—	12	8	—	—	—	—	—	—
Moore Sch. E. E.	3	—	65	—	68	1	3	3	5	—	11	—
Nebr., Univ.	1	2	—	—	3	0	4	—	—	—	4	1
N. H., Univ.	—	2	—	—	2	0	—	—	—	—	—	—

Moore Sch. E. E.	3	—	65	—	68	1	3	3	5	—	11	—
Nebr., Univ.	1	2	—	—	3	0	4	—	—	—	4	1
N. H., Univ.	—	2	—	—	2	0	—	—	—	—	—	—

Enrollment of Graduate Engineering Students, 1936–37—Continued

Institution	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Professional)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
No. Car., Univ.	2	—	—	—	2	—	—	—	—	—	—	—
No. Car. St. Coll.	4	—	—	—	4	—	—	—	—	—	—	—
Notre Dame, Univ.	2	0	0	0	2	0	—	—	—	—	—	—
Ohio St. Univ.	33	14	—	—	47	29	13	12	—	—	25	4
Okla. A. & M. Coll.	0	6	0	0	6	0	—	—	—	—	—	—
Okla., Univ.	9	—	—	—	9	2	—	—	—	—	—	—
Ore. St. Coll.	14	2	—	—	16	8	—	—	—	—	—	—
Pa. St. Coll.	3	—	—	23	26	8	—	—	—	2	2	3
Pa., Univ.	2	—	29	—	31	3	—	—	1	—	1	—
Pittsburgh, Univ.	8	69	0	0	77	9	0	11	0	0	11	1
Princeton Univ.	11	1	—	—	12	—	—	—	—	—	—	—
						9*						
Purdue Univ.	27	26	—	—	53	34	4	6	—	—	10	1
Renss. Poly. Inst.	14	—	—	—	14	12	5	—	—	—	5	2
Rochester, Univ.	1	—	—	—	1	—	—	—	—	—	—	—
Rutgers Univ.	—	7	—	—	7	3	—	—	—	—	—	—
So. Dak. Sch. Mines	1	3	—	—	4	0	—	—	—	—	—	—
Stevens Inst.	2	14	—	—	16	9	—	—	—	—	—	—
Swarthmore Coll.	1	—	—	—	1	0	—	—	—	—	—	—
Syracuse Univ.	3	—	—	—	3	3	—	—	—	—	—	—
Stanford Univ.	65	—	—	—	65	21	—	—	—	—	—	1

Enrollment of Graduate Engineering Students, 1936–37—Continued

Institution	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Professional)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Texas Tech. Coll.	4	1	—	—	5	4	—	—	—	—	—	—
Texas, A. & M. Coll.	8	13	—	—	21	13	—	3	—	—	3	—
Texas, Univ.	4	13	—	—	17	13	—	—	—	—	—	—
Tulane Univ.	11	—	—	—	11	—	—	—	—	—	—	—
Utah, Univ.	5	—	—	—	5	6	—	—	—	—	—	—
Union Coll.	0	0	0	0	0	—	0	0	0	0	0	—
Va., Univ.	2	—	—	—	2	1	—	—	—	—	—	—
Va. Poly. Inst.	40	7	—	—	47	25	—	—	—	—	—	—
Wash. Univ. (St. L.)	7	—	—	—	7	5	—	—	—	—	—	—
Wash., Univ.	27	—	—	—	27	12	1	—	—	—	1	—
Wash. St. Coll.	3	—	—	—	3	1	—	—	—	—	—	—
W. Va. Univ.	4	1	—	—	5	2	—	—	—	—	—	—
Worcester P. I.	3	3	—	—	6	4	—	—	—	—	—	—
Yale Univ.	17	1	—	1	19	4	15	4	—	—	19	5
	1049	424	528	98	2099	735	241	107	11	3	362	82
CANADIAN												
Queen's Univ.	5	1	—	—	6	4	—	—	—	—	—	—
Sask., Univ.	3	1	—	—	4	4	—	—	—	—	—	—
Toronto, Univ.	13	—	—	—	13	12	7	—	—	—	7	1
	1070	426	528	98	2122	755	248	107	11	3	369	83

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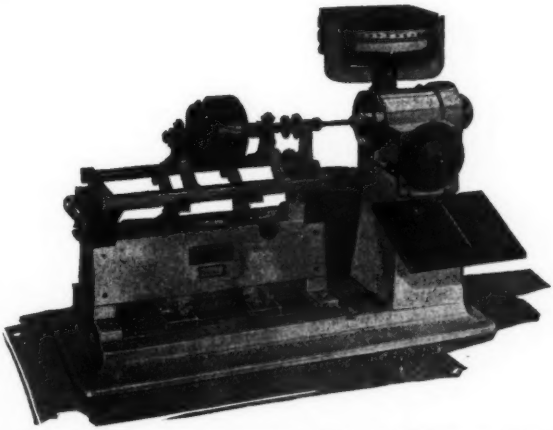

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